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INFANTRY WEAPONS TEST METHODOLOGY STUDY.

~~FINAL REPORT~~

VOLUME III.

LIGHT MACHINE GUN TEST METHODOLOGY.

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# INFANTRY WEAPONS TEST METHODOLOGY STUDY

## FINAL REPORT

## VOLUME III

## LIGHT MACHINE GUN TEST METHODOLOGY

JUN 1972

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FORT BENNING, GEORGIA 31905

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## APPENDICES

I. Infantry Machine Gun Methodology Review

II. Operational Test Procedures and Techniques

III. Technical Data Package for Test Facility Expansion

IV. Additional Target Presentation Scenarios

1. INTRODUCTION AND SCOPE

a. Introduction - Volume III of the Infantry Weapons Test Methodology Study summarizes findings concerning the testing of light machine gun (LMG) weapon systems. This volume is accompanied by four appendices: Appendix I, produced by Infantry Board personnel, provides guidance and background material for the methodology study; Appendix II summarizes the major findings, which are discussed in this report, in terms of a procedures manual for the operational evaluation of light machine gun systems. Appendix III is a Technical Data Package for the additional targets required to expand the defense facility to accomodate light machine guns. Appendix IV consists of the necessary target presentation scenarios to complete the set required for LMG evaluation. This document is the third in a series of reports on methodology studies for Infantry weapons. Volumes I and II summarized findings concerning rifles and antitank weapon system evaluation, respectively. Volumes IV and V, scheduled for production during the next 4-month period will summaraize findings concerning the operational testing of grenade launchers and indirect fire weapons.

b. Scope- The methodology study was conducted by the US Army Infantry Board to insure that Service Test Concepts have kept pace with training, doctrine, and development concepts. The study was guided by four basic technical objectives which are paraphrased below. (The study directive, which describes the goals of the study in detail, appears in Appendix I of Volume I.)

(1) Determine those factors influencing the evaluation of Infantry weapons in a realistic combat environment.

(2) Develop techniques and methods to measure critical factors influencing weapon system performance.

(3) Isolate those factors which are subjective, involving judgement and experience, and which are not amenable to measurement, and establish the relative importance of each.

(4) Develop automated test facilities which will permit operational testing with minimum of maintenance and support.

A thorough treatment of these four objectives required consideration of many factors. First and foremost was that machine gun evaluation must be oriented toward the combat tasks and actions required of the system when employed on the battle field. Any test facility which is designed to simulate actual combat must include as many relevant factors as possible. Next, adequate measures of effectiveness were developed which are used to quantify performance of competing weapon systems and which provide the data base for decision making. Factors which cannot be measured must be accounted for subjectively; these were identified and experimental designs were established which take these factors into account either through balancing, as in the case of weather factors, or by assuming that the factors will have an equal impact on all competing weapons. Variables such as stress and suppression fall into this category. Last, test facilities were designed which take into account all of the above factors in an effort to represent a realistic combat environment for machine gun testing. The facility duplicates the types of targets the machine gun is employed against in terms of the ranges, exposure time, numbers and disposition.

Of particular interest was crew/weapon interface. The machine gun system is more complex than the rifle system since the operator must interface with the weapon and, at times, an assistant gunner. The crew in turn, must interface with the weapon on a variety of weapon mounts performing several combat tasks. This complicates the development and interpretation of measures of effectiveness.

This entire study was devoted to improving service test procedures through the four basic objectives. The following definition of a service test, quoted from TECOM Regulation 705-11, was used to define the scope of the machine gun test methodology study.

> "A test conducted under simulated or actual field conditions where the objective is to determine to what degree the item or system and its associated tools and test equipment perform the mission described in the QMR, and the suitability of an item or system and its maintenance package for use by the Army. This test is characterized by qualitative observations and judgement of selected military personnel having a background of field experience with the type of materiel undergoing test, with instrumentation limited to those measurements of characteristics of major operational significance. The test is conducted using soldiers representative of those who will operate and maintain the equipment in the field. The service test provides the basis for recommendations on type classification."

2. BACKGROUND

a. Purpose of the Report - The purpose of this report is to summarize, under a single cover, efforts and findings concerning light machine gun test methodology, which have been performed with contractual support provided by the Mellonics Division of Litton Industries, Inc., Contract Number 18-68-C-004.

b. Chronology. The first four years of the methodology study were oriented toward the improvement of small arms test techniques and procedures. Since the light machine gun is a member of the small arms family of weapons, much of this work is directly applicable to machine gun performance testing. The major events during the first four years were the development of the three small arms test facilities (attack, defense, and quickfire), which although primarily designed for rifle testing, have considerable utility for machine gun testing. The dates of completion for these facilities are described below. The completion of the Machine Gun Methodology Review was another major milestone in the LMG study. Other major carry-overs from the small arms methodology study were the development of target systems, both moving and stationary, and the design and procurement of an automatic data acquisition system.

During the final year of the study, major efforts programmed are the addition of long range targets on the defense facility designed specifically for machine gun performance evaluation, the development of target presentation scenarios which are described in Appendix IV, and the development of machine gun performance evaluation procedures and techniques described in Appendix II. The major milestones are summarized chronologically below:

Feb 1966 - Completion of the Attack Facility

Oct 1968 - Completion of the Quickfire Facility

Jun 1970 - Acquisition of ADPE

Sep 1970 - Machine Gun Methodology Review

Dec 1970 - Completion of the Defense Facility

Feb 1972 - Addition of Long Range Targets to Defense Facility

3. EXECUTIVE SUMMARY

a. The resources expended on the Machine Gun Test Methodology Study can be can be categorized into two specific efforts: (1) A study of operational testing of small arms to apply results of improved small arms test procedures to machine gun weapon system evaluation, and (2) expansion of the test facilities to permit more realistic tactical scenarios to be used during machine gun testing. The two steps were not done independently; the findings from the study dictated the additions to the test facilities.

b. From the Infantry Machine Gun Project Review, which identified all combat actions performed by Infantry units in which machine guns are normally employed and which delineated all the specific tasks required by the operator and/or crew, a test design was prepared. The design specifically examines the three major techniques of employment used with the machine gun: unsupported firing (hip position, underarm position, and shoulder position), bipod supported position and tripod mounted position. Only direct fire tests are employed removing from consideration

over next page

position defilade firing. Emphasis was placed on those characteristics of the machine gun which strongly enhance its value on the battlefield:

(1) To produce a heavy volume of direct fire.

(2) To deliver grazing fire out to 600 meters.

(3) To produce sustained fire for prolonged periods.

(4) To engage targets at extreme ranges.

(5) To deliver accurate predetermined fire based upon ~~direction~~ deflection and elevation data.

The fighting unit attempts to exploit these characteristics especially on the forward edge of the battlefield in order to have maximum unit effectiveness in the delivery of long range fire, close defensive fire, and final protective fire. An operational service test that fails to take these factors into account is not oriented to the principle mission of the machine gun.

c. Two test facilities are employed in the design: quickfire and defense. All ground-to-ground combat actions can be accounted for on tests using these two facilities. Ground-to-air and air-to-ground combat actions are not considered in the current design since adequate test ranges are not available at Fort Benning. Each of the major influencing factors is described in the next section, as are the measures of effectiveness, subjective factors, and instrumentation. Range modifications to accomodate operational machine gun testing are discussed in Section 5; the Technical Data Package which prescribes these changes in terms of specific instrumentation appears as Appendix III. Appendix II contains a suggested test procedure which incorporates the major findings of this study in a test format for use in the field evaluation of machine gun weapon systems.

d. Since there has been considerable carry-over from the Small Arms Methodology Study, it is difficult to estimate the manpower that has been expended in support of the machine gun portion of the study. Installation of additional targets on the defense facility will require approximately 4 man-months of contractual support. Preparation of the integrated test procedure, this volume of the report and the Technical Data package required approximately 5 man-months. Excluding carry-over knowledge and experience from the small arms methodology study, approximately 11 man-months of the current program will have been oriented directly toward the Machine Gun Methodology Study.

## 4. TECHNICAL OBJECTIVES

The support contract for the Infantry Weapons Test Methodology Study specifically states that four technical objectives will be focused on during the study. The efforts and findings in pursuing each of these objectives appears in the following paragraphs. A discussion of each of the major influencing factors appears under Objective 1. Techniques for measurement and testing weapons quantitatively accounting for as many of the influencing factors as possible are described under Objective 2. A discussion of factors which must be treated qualitatively appears under Objective 3. Finally, a description of instrumentation, calibration and controls appears under Objective 4.

### a. Technical Objective 1.

(1) Introduction - The first technical objective of the Infantry Weapons Test Methodology Study is given below:

> Determine those factors which are critical to the evaluation of machine gun weapon systems in a quasi-tactical environment.

The determination of factors influencing the evaluation of machine guns in a realistic combat environment was accomplished through analysis of the knowledge acquired during the small arms phase of the study. No field experiment was run to test scientifically the findings described in the following paragraphs. However, three small arms field experiments described in Volume I of this report were accomplished and, since the machine gun is a member of the small arms family of weapons, much carry-over is available from these sources. The major influencing factors are:

(a) Weapon Evaluation

(b) Human Factors

(c) Sample Size

(d) Soldier Selection

(e) Weapon Assignment

(f) Training

(g) Vulnerability

(h) Combat Action

Each of these critical factors should be an integral part of operational testing.

The rationale for including factors b through g above differs little from that discussed in Volume II and, consequently, the implementation or incorporation of these factors into field testing is discussed only briefly in the following paragraphs. Discussed in detail are weapon system evaluation and the combat actions.

(2) Weapon System Evaluation - Developing operational evaluation techniques and procedures for machine gun evaluation was complicated by the variety of combat actions required of the weapon system. Any valid operational evaluation would require performance evaluation under a large number of these tasks. Consequently, the resulting test procedure is relatively long and consists of many subtests.

The major influencing factors isolated in the examination of machine gun roles was the manner in which the weapon is employed by the gunner/crew. There are five basic methods, each requiring the individual(s) to interface with the weapon in a different manner. The interface between the operator and the weapon was found to be the focus of the operational test. Earlier testing phases of the test cycle focus on engineering and mechanical characteristics of the weapon. The service test focuses on the entire weapon system, which includes the gunner or crew. Given two or more competing weapons with specific mechanical characteristics, the service test attempts to measure the performance of the weapon and the individual or user together. Therefore, the manner in which the weapon is employed is of extreme importance. The five methods of employment are:

Tripod mounted weapon

Bipod mounted weapon

Vehicular mounted weapon

Pedestal mounted weapon

Free gun

In addition, there are six types of fire classified with respect to the weapon system: fixed, traversing, searching, traversing and searching, swinging traverse, and free gun. With respect to the target, there are four types of fire: frontal, flanking, oblique, and enfilade. With respect to the ground, there are two types of fire: grazing and plunging. Further, the weapon may be operated with a single gunner or with a crew which consists of a gunner and assistant gunner.

Thus far, the factors discussed if included in a factorial design would require a matrix with

$$5 \times 6 \times 4 \times 2 \times 2 = 480 \text{ cells}$$

Yet to be included in the design are such factors as tracer mix, combat action, terrain, measures of effectiveness, target action, and range.

The service test cannot include all possible combinations of variables. Consequently, representative combinations have been selected upon which weapon system performance evaluation is made. In some cases, two or more combat actions require an identical set of crew/gunner tasks. Under these conditions one of the tasks was deleted thus simplifying the design without loss of validity. The specific set of combinations, described under Objective 2, is representative of the combat tasks required of a machine gunner or machine gun crew. Where possible, the combinations have been specifically selected because they require individual performance identical to that required in combat.

Objective 2 describes specific subtests for machine gun performance evaluation. Factors accounted for are:

Type of mount

Type of fire

Rate of fire

Burst size

Range

(a) Type of Mount - Machine guns are normally employed as a free gun fired from the hip, underarm, and shoulder position, or fired from one of several mounts, tripod, bipod or pedestal. Each method requires different actions on the part of the crew. Consequently, a thorough evaluation will require use of strong sample of firing positions. Each of the above is included in one or more subtests except for the pedestal mount, where the gunner's tasks are similar to the tasks required when using tripod and bipod. Therefore only two mounts are used in addition to the three gun positions.

(b) Type of Fire - The target arrays selected for use during machine gun evaluation are sufficiently large to require several adjustments to the weapon. Two mount adjustments are required in the subtests: fixed, and traverse and search. The adjustments required while performing the traverse and search task are similar to those required when the search and traverse actions are done individually, thus permitting the elimination of the single tasks without the loss of valuable variables from the design.

(c) Rate of Fire - Most of the firing in the subtests use the sustained rate of fire which is 12-13 bursts of 6-9 rounds each with 3-4 second pauses between bursts. Using this rate permits consumption of a reasonable amount of ammunition for a sustained fire fight. Target presentation scenarios vary with the subtest but an attempt is made to provide a reasonably long test, one that taxes the capability of the gun to withstand heat buildup. One subtest is designed to test ease of barrel change while engaging in a fire fight. This subtest uses the rapid rate of fire, 26 bursts of 6-9 rounds each with 1-2 second pauses between bursts. At this rate, a barrel change is normally required after each minute of firing.

(d) Burst Size. Six to nine rounds per burst has proven through experience to be optimum number of rounds which can be fired with accuracy. This burst size is recommended for all firings in which a mount is used. When using the free gun offhand position, the test soldier will be instructed to use a burst size that he feels is most effective not exceeding 9 rounds per burst. Data analysis will determine whether burst size is related to effectiveness.

(e) Range - The engagement ranges are varied according to the objective of the subtest. Fixed firing techniques or search and traverse require that targets be placed near the maximum effective range of the weapon. For these subtests, range will be from 400 and 1000 meters. For off hand firing, ranges will be as close as 20 meters. This approach is designed to permit performance comparisons over a broad spectrum of engagement ranges, without having to perform each type of firing at every range. Again, this will reduce the number of cells in the design matrix without loss of validity.

(3) Human Factors - The most serious shortcoming from a test validity standpoint of the simulated combat environment is the lack of credible threat to the user of the weapon. Factors affected include stress, motivation, and suppression.

The use of stress substitutes, such as physical fatique or sleep deprivation, does not appear to be the answer to this problem since no stress substitutes produce the characteristic adrenalin augmented response produced by extreme fear. Rather, stress substitutes will likely reduce motivation which in turn may not be consistent with combat behavior. Extreme fear may be a tremendous source of motivation either to fight or to run. Since the fighter is of primary interest, the test soldier should be highly motivated to perform at his best in the service test. Hence, stress substitutes which could have a possible inhibiting effect should not be used in order to achieve maximum motivation on the part of the test soldier. The elimination of stress may not be a severe constraint since combat soldiers are likely to behave in a similar manner regardless of the weapon they have providing the weapon differences are relatively small, e.g., two closely competing light machine guns.

The final human factor is suppression -- perhaps the least understood characteristic of weapon performance. All things being equal, the weapon with the loudest, most easily observed signature on impact or in the impact area will probably be perceived as having the greatest suppressive effect. However, the most lethal weapon may be a silent weapon and the psychological impact of a silent weapon is just not known. Consequently, the incorporation of suppressive capability as a weapon effectiveness measure is not within the state-of-the-art at present. Rather than the base a method of using suppression as a factor in decision making on unfounded criteria, the recommendation is to exclude suppression from consideration until more knowledge is available.

(4) Sample Size - The optimum sample size for rifle testing was established at 96 weapon systems of each type being tested. The sample seems large, but, when the cost of a new rifle system and the magnitude of the risk inherent in selecting the wrong rifle is considered, the size is easily justified. However, the number of prototype machine guns available for the test will normally be far fewer than the number of rifles available. Consequently, out of necessity, another approach weapon evaluation is required. The few weapons that will be available will require more than a single crew and the number of tactical scenarios under which the tests are to be conducted will be broadened. More information concerning the performance of each weapon system will be required to account for the fewer weapon systems available for testing.

As mentioned above, the suggested sample size for rifle testing was 96 soldier/rifle systems. This sample size was determined empirically from data generated on the test facilities. No such data exists for machine gun systems, consequently, without a pilot study only the crudest guess can be made. Factors that affect sample size were considered. A decrease in variability is suspected due to the stability of the mount and the weight of the weapon. An increase in the number of hits is predicted because of the increase\ firing rate. If the 25 per cent improvement criterion is used, it is expected that sample requirements will be reduced considerably. Therefore, a range between 36 and 48 is selected as the appropriate sample depending on requirements for balancing the design with reference to test facilities and subtests.

Further, it is expected that the number of weapons available for testing will be far less than the 36-48 required. Consequently, weapons should be rotated among several crews. For example if six weapons are available, 6 to 8 crews should be trained and tested using each weapon. For a full scale machine gun evaluation, a pilot study to determine precise sample size is recommended.

(5) Soldier/Crew Selection - Thirty-six soldier/crews will be required for the evaluation of the machine gun weapon system. These personnel should be selected from the universal population of infantry soldiers who have had Advanced Infantry Training or combat experience.

Other factors to be considered are rank, MOS, age, as well as other characteristics such as right or left handedness, corrected or uncorrected vision. The sampling procedure recommended is to acquire from the supporting unit the 201 file of each qualified Infantryman. The 201 files should be examined and extreme members of the group with respect to age, IQ, height, and weight should be removed from the population. Extreme is defined as those members who exceed $1\frac{1}{2}$ standard deviations from the mean with respect to any variable. Further, for the purpose of this service test, people who are left-handed or have corrected vision should be removed from the sample. The rationale for this last step is dictated by the fact that people whose eye sight is unquestioned are normally assigned the responsibility of handling a machine gun and, if the weapon is more easily handled by a right-handed individual, only right-handed Infantrymen will be assigned the role of machine gunner. From the remaining population, random selection should be used to acquire 36 gunner/crews for each weapon system. Crews should be assigned to specific weapon types by random procedure also.

(6) Weapon Assignment - Prior to the start of the training program, weapon crews should be assigned to the candidate weapons. Either of two methods may be used. Soldiers may be assigned by using any of the accepted methods of random assignment based on chance. Or, firing tests with the candidate weapon can be set up; each crew fires for record on a 25-meter range. From these firings, the two crews with the tightest shot group are assigned randomly, one crew for each weapon. The two crews with the third and fourth tightest shot groups are similarly assigned and so on until all crews are assigned.

(7) Training - Results from previous experiments conducted during the small arms methodology study indicate that training can introduce a significant bias into weapon evaluation. The best safeguard is an extensive training program for the weapon crews. Experience indicates that 2 weeks of training are required and that the content of the training course should closely follow the machine gun oriented material in the Advance Infantry Training Course. The critical factor appears to be length of time. The training period should insure that the machine gun crews have attained the same degree of familiarity relative to the test weapons.

(8) Combat Action - The effectiveness of the machine gun is dependent on the type of action taking place, especially when the primary Measures of Effectiveness (MOE) is number of enemy kills. The measures are discussed under Objective 2. The number of kills is dependent on the terrain, number of exposures, length of exposures, movement speed, and range. Terrain and range are accounted for on the test facilities which are built on representative terrain providing gunners with normal combat cues on feedback; reference points such as creek channels and trees are present to provide range estimation cues. Care has been taken to insure that the facilities are not open, flat, known distance ranges.

Targets have been positioned to provide a full, representative set of ranges or firing distances. The other factors, however, are scenario dependent factors.

The use of target hits which represent enemy kills is only useful to the extent that the simulated combat facilities represent real combat. Soldiers must be required to perform the same tasks on the facilities that they would be required to perform in combat. These tasks include coping with smoke and haze from the weapon, detecting and hitting elusive targets, reloading or changing barrels on a hot weapon, and at the same time, trying to maintain maximum effectiveness against the enemy. The less realistic the scenario, the more difficult it becomes to generalize the results from the simulated combat environment to the real combat environment.

The initial step in determining scenario requirements was to examine the combat actions. Ten such actions are associated with the defensive situation and are reduced or folded into three basic actions:

| Combat actions | Basic action |
| --- | --- |
| Combat outpost<br>Delaying action<br>Roadblock<br>Retrograde operations<br>Collapsing defense | Retrograde Operations |
| Ambush<br>Deliberate defense | Deliberate Defense |
| Consolidation<br>Hasty defense<br>Area security | Hasty Defense |

Examination of the combat tasks required to perform these actions shows that the tasks are essentially identical, the basic difference in the three actions being amount of position preparation, e.g., ammunition stockpiling and crew cover. The required crew firing tasks for all three actions are listed below:

Long range grazing and plunging fire

Medium range grazing, sustained fire

Final protective fire

Rapid displacement of weapon

All three actions require rapid displacement of the machine gun. Displacement is used in the deliberate defense to reduce the probability of the enemy pinpointing the weapon system. In the other two actions, rapid displacement is required to break off action as in a delaying action or collapsing defense.

The scenarios selected for the defense facility, which are described in each of the subtests, are designed to cause the machine gun crew to perform the tasks required against realistically presented targets.

Seven combat actions are folded into a single action on the quickfire facility:

Close combat

Counterambush

Security of a moving column

Search and clear

Combat patrol

Reconnaissance patrol

Combat in cities

Advance to Contact

The combat tasks characterized by these actions are, again, identical: anticipated medium to short range enemy contact, rapid situation estimates, rapid firing reaction, and immediate, aggressive action against targets of opportunity. The quickfire facility is designed specifically to produce these data.

Other combat actions can be performed by the light machine gun weapon system; these are fire and movement, frontal assault, and fire support, all of which are part of the combat attack. The fire support action is similar enough to defensive actions, in terms of the tasks required, to eliminate this action, or, rather, to fold this action into those performed on the defense facility. If the machine gun is designed or is suitable for the fire and movement and frontal assault roles, an attack facility should be used.

A specific subtest using the attack facility has not been outlined since machine guns produced to date are relatively ill-suited to use with the maneuver element. Range problems exist with the submachine gun which is designed for close combat (i.e., quickfire-type actions) and portability of weapon and ammunition make the light machine gun more suited to the supporting role in the attack.

b. Technical Objective 2.

(1) Introduction - This task encompasses the selection and use of the performance measures to be employed in machine gun weapon system tests. The objective is concerned with execution of the tests:

> Develop the techniques and methods for generating meaningful numerical measurements of critical factors on a real time basis, i.e., determine instrumentation, sample sizes, calibrations and controls, while permitting unimpeded tactical movement of the test soldiers in a reasonably realistic environment.

The approach used here is to evaluate machine gun weapon systems in a series of independent subtests. Each crew/weapon combination (36 per weapon type) is to perform each of the subtests. The instrumentation required is that which is already an integral part of the small arms test facilities, primarily round count and hits. Suggested target presentation scenarios for each subtest are provided to insure that sufficient types of data are collected to use the available measures of effectiveness. The MOE and corresponding analytical plan is described in paragraph (2) and (3) below; paragraph (4) contains a description of the subtests; instrumentation calibration and control are discussed under Objective 4; sample size and related factors were discussed under Objective 1, above.

(2) Measures of Effectiveness - The objective of the service test is to select from candidate weapon systems the most effective combat weapon. Many measures have been developed to provide information for use in making this decision. However, the number of measures and their degree of interrelatedness, which is unknown, makes objective selection difficult. The data can be produced objectively, but the weighting of the various measures is a subjective influence which affects the final decision.

To reduce subjectivity, an attempt was made to develop a comprehensive measure of effectiveness which included the specific measures in such a manner that their weights were naturally accounted for. The measure common to the combat situation, which is dependent on the weapon system being used, is the number of enemy kills. If the target presentation scenarios are realistic, requiring gunners of crews to accomplish the same tasks required in combat, then the number of targets hit can be equated to enemy kills. This general measure includes such categories of MOE as accuracy, responsiveness, sustainability and reliability. Weapons weak in any of these categories will fail to achieve maximum effectiveness providing that the scenarios are realistic in terms of targets presented, target exposure times, and length of fire fight.

The individual MOE are still available for analysis and especially determination of cause and effect. A thorough analysis will include not only the identification of the superior weapon system, but should include rationale for good and poor performance of all competing weapons. Direct comparison will permit identification of weak performance areas and, hence, lead to possible improvements.

(3) Analytical Plan.

The analytical plan revolves around six day-defense scenarios, two-night defense scenarios and a quickfire facility test. The initial analysis is based on the six day-defense scenarios which represent the most important combat functions of the machine gun weapon system in terms of numbers of actions, frequencies of actions, and the importance of the machine gun role in the actions. Using the number of targets hit as the primary MOE, machine guns are compared as a function of the six day defense scenarios. If at the conclusion of the initial analysis no significant performance difference has been isolated, the analysis will continue using individual measures of effectiveness. The night subtests and the quickfire facility subtests will also be used. The analytical plan is described in detail in Appendix II.

(4) Subtests - The subtests are subdivided into three basic sets according to the type of mount used. This method of subdividing tests is for convenience in describing tests. The actual schedule for implementation is a matter of convenience, but the schedule selected should be consistent for all test weapons. (The analysis, as described above, is based on the relative importance in the combat environment: day defense, night defense, and advance to contact or quickfire.) The subtests are further divided into specific tests. Each test description includes the scenario, the basic test objective, schedule, and the means of accomplishment. Each uses the basic sample of 36 gunner/crews and six weapons, although adjustments may be made to meet constraints. The subtests are described in Appendix II.

c. Technical Objective 3.

(1) Introduction - The third technical objective of the Infantry Weapons Methodology Study is stated below:

> Attempt to isolate those factors which are subjective, involving judgement and experience and are not amenable to measurement from those which are, and establish the relative importance as contributing to effectiveness. The use of interim "breadboard" facilities

is desirable to determine the feasibility of this testing methodology, and to explore variable and techniques. These devices will utilize movable structures, basic electromechanical devices and instrumentation. Existing computer or programmer capability will be used when available for supporting the study and determining permanent requirements.

The development of the concept of using a scenario dependent, single measure of effectiveness reduces much of the subjectivity normally associated with weighting the various MOE in terms of importance. The weighting is taken care of realistically and automatically during the conduct of the simulated tactical exercise. However, some judgment will be required to determine which combat actions should be duplicated and how the action can best be represented by the test facility. Other factors include signature effects, portability and compatibility, durability and stability. These factors are discussed below.

The feasibility of the test methodology prescribed here is based on the results of the small arms methodology study. Initially, an attack small arms test facility was constructed to determine the feasibility of developing improved methodology. A breadboard quickfire facility was subsequently designed and constructed. Finally, since the test facilities proved that improved test procedures and techniques were a feasible goal, a more permanent defense facility was constructed utilizing basic electro-mechanical devices configured in removable and replaceable subsystems. The attack and quickfire facilities were subsequently improved, replacing the breadboard facilities with hardened, more permanent facilities.

(2) Scenario Development - Using the technique described in the previous objectives, the primary subjective factors becomes the design of realistic actions. To estimate combat performance capability, the testing situation must be as much like combat as possible. The gunner/crew must be required to perform tasks identical to those found in the combat environment. Targets must be elusive and difficult to hit. This is accomplished by using realistic exposure times and a realistic arrangement of targets. The required physical facility is described under Objective 4.

Therefore, the scenarios used in the subtests described in Appendix II require the use of experience and judgement in their design and development. A combat task that calls for long-range traversing and searching targets must be realistically duplicated in a controlled scenario. Firing distances and exposure times must be representative of those found in combat.

Another problem that requires the use of experience occurs when one competing weapon fails to produce consistently superior results for all scenarios. This phenomenon is known as an interaction effect between weapons and tactical problems. Should this occur, the relative combat importance of the tactical problems will have to be weighted. The normal procedure is to use frequency of occurrence and the consequences of outcome to determine which scenario should be considered most important. The scenarios can then be weighted and a model similar to the following could be used:

$$\begin{bmatrix} \text{Scenario } 1 \\ \text{Hits} \end{bmatrix}^{\frac{1}{a}} \begin{bmatrix} \text{Scenario } 2 \\ \text{Hits} \end{bmatrix}^{\frac{1}{b}} \begin{bmatrix} \text{Scenario } 3 \\ \text{Hits} \end{bmatrix}^{\frac{1}{c}} = P_a \text{ MG A}$$

where the powers are the expressions for relative importance, the most important being 1, the second most important being 2, and so on. If $P_a$ is higher than $P_b$ (MG-B), A should be selected. This model need only be used if interactions occur during the analysis, described briefly under Objective 2.

(3) Signature Effects - Daylight and limited visibility signature effects are an extremely important consideration, since the machine gun's vulnerability is directly related to its effectiveness. Normally, tests performed during the engineering test phase will uncover major deficiencues in this areas. However, either a subjective or a programmed evaluation of the weapon signature should be made to insure that the competing weapons are not distinctively different. If differences are evident, either modifications to correct the deficiency or a technique to incorporate the difference as it affects the weapons capability are required. Such a model is described in the Antitank Methodology Study, Volume II of this report, under Technical Objective 3, which can be employed to assist the decision maker in accounting as objectively as possible without instrumentation.

(4) Portability and Compatibility - This is an especially important variable in the analysis of machine gun effectiveness. In order to be effective in combat, the weapon, mount, and ammunition must be readily transportable.. One technique for measuring this characteristic is to use time trials over an obstacle course. Another has already been incorporated into the subtests described above, the ability to displace to an alternate position. In this latter case, the decision concerning the impact on effectiveness is made automatically since poor portability and compatibility characteristics will show up as fewer kills due to restructions on firing time. The ability to get the system into the combat area is measured on an obstacle course, the weight to be placed on this variable is subjective. This variable is only a problem if difference between weapons are significant which should not occur because

of the similarity of light machine gun with respect to weight and handling characteristics. The factors listed below are normally associated with rapid displacement and employment of the weapon:

Traversing and elevating mechanism

Vibration

Heat of component

Ease of loading and charging

Obscuration

Ammunition carrying carrying cases

Weight of components

Location and use of sights

(5) Durability. This variable is a measure of the weapons ruggedness and ability to withstand the rigors of the combat environment. It is not accounted for sufficiently on the test facilities alone. Durability data should be collected during all phases of testing: performance, obstacle, and extended road marching. The relative importance of durability is very high when compared to stability and reliability, since a malfunction normally means an end to the weapons effectiveness. Reliability malfunctions normally mean a temporary suspension of effectiveness while stability problems usually mean sustained but reduced effectiveness. Each of these factors can be measured to some extent, but their relative weight remains subjective.

(g) Stability - Mount stability problems are usually associated with the pedestal and tripod mounts and are isolated with such measures as time between bursts, length of burst and hit probability. The effect of stability problems is accounted for partially in the primary measure of effectiveness, since stability problems will likely reduce hits on targets. However, experience is the best means of determining that such problems exist since the crew may not always be aware of the problem. Careful scrutiny by the test officer is required whenever possible to assist in isolating causes of stability problems. Probable causes are:

Loose soil

Worn parts

Vibration

(7) Relative Importance of Subjective Variables - In many cases the subjective variables are, at least, partially accounted for in the primary measure. Such variables as accuracy and responsiveness make themselves felt in number of targets hit. Likewise, so does sustainability and reliability, providing scenarios are sufficiently long to be realistic. Portability and compatibility, durability, and stability are also felt in the primary measure, although cause and effect are somewhat difficult to observe; since differences are likely to be small, experience is important in isolating and establishing the relative importance of them. Normally, the more terminal the factor, the greater weight the variable should receive. That is, durability should receive greater weight than stability and so on. The key to determining the weight of the factors is the impact on the tactical situation, that is, the number of minutes the weapon is out of action during the simulated firefight.

d. Technical Objective 4.

(1) Introduction - The fourth objective of the Infantry Weapons Methodology Study is oriented toward the test facilities on which the operational performance of competing weapon systems can be estimated. The objective is stated in the directive for the study as follows:

> As a final objective, the foregoing results are eventually intended for application to automated ranges which will permit imposition of programmed field operational tests while recording and analyzing test data, and displaying results with a minimum of maintenance and technical support.

As with small arms, the project has realized more progress in this area than was originally expected. The final objective of eventually using the results for programmed operational field tests in automated test facilities is within reach. Only minor additions to the existing facilities are required to test machine guns; namely, the addition of long range targets. Flexibility in firing positions is already sufficient to accomodate machine gun testing as described under Objective 2; the software and ADPE are compatible with minor modifications to analyze and display test data. No additional calibration is required.

(2) Instrumentation - Instrumentation which is available for use in machine gun operational testing is described briefly in the following paragraphs.

(a) Round Count - The defense and quickfire facilities are equipped with round count systems which are capable of handling rates of fire to 6000 rounds per minute. Round count sensors which are connected by hard wire to the ADP van are located at each firing position on the facilities. Should the attack facility be used in testing light machine guns, a helmet mounted radio round count system is available. The counting rate is identical to the one described above. No modifications to this system are required. The helmet mounted attack facility round count can be used for vehicle-mounted weapons. No specific vehicle-mounted test is equipped to handle vehicle-mounted weapons although range safety plans will have to be approved. The current access road will provide a firing trail for the weapon to advance from firing position to firing position to engage preselected sets of targets or to fire while the vehicle is passing through premarked firing zones. Firing while moving laterally can be accomplished by using the anti-erosion terraces or a path directly behind the night firing positions.

(b) Hit Scoring - All targets are made of a hit scoring material to provide basic hit data. Stationary targets are hardwired to the ADP van; moving targets use a radio data link to the van. Hit counting rates exceed 6,000 rounds per minute.

(c) Near Miss Data - Near miss data (to approximately 7 feet from the target) are available for supersonic rounds (5.56 and larger). Miss distance is available in X, Y coordinates. Each target on the quickfire facility is equipped with an array of sensors. A single target in arrays on the defense facility is equipped with miss distance sensors to provide these data on a sampling basis. These data are not available for current .45 caliber submachine guns because the round travels slower than the speed of sound and hence, does not produce the required sonic wave.

(d) Other Data - Other data required for a particular test are available but must be specified. These data include firer personal history, reliability data, movement speed data for both carrier and target, ambient light levels, and target background contrast data. To acquire these data, suitable data collection forms must be designed. These forms may be patterned after similar forms used during each of the small arms tests. Samples of these forms appear in the appendices of the experimental design documents which appear in Appendix IV, Volume I, of this report.

(3) Calibration and Control - No calibrations are required since each sensor is designed to operate on a go/no go basis, the exception being the low light level measuring equipment and laboratory instrumentation (electronic counter, oscilloscope) which require periodic inspection and calibration. Controls to insure reliability are handled automatically by Methodology and Instrumentation Branch personnel. Round count accuracy is verified by using duel systems on a sampling basis; hit count accuracy is verified using witness paper over selected targets and comparing the resulting manual hit count with the computer count. Verification of manually recorded data is the responsibility of the test officer.

(4) Computer Software.

(a) Target Presentation Scenarios - The USAIB compiler is available for producing any scenario programs desired by the test officer. Several sample scenarios or a scenario description accompanies each subtest, but alternate scenarios may be written for compilation. Two helpful documents which may be found in Appendix VIII, Volume I, are the Compiler User's Guide and Scenario Optimization Manual for the Defense Facility.

(b) Sorting and Basic Record Software - Software exists for preparing a basic record for each round fired on the test facilities. The record provides the necessary information to produce the measures of effectiveness for the machine gun weapon system. A modification to accomodate burst sizes of up to 100 rounds will have to be made to the software before the small arms data programs are completely compatible with the characteristics of the machine gun.

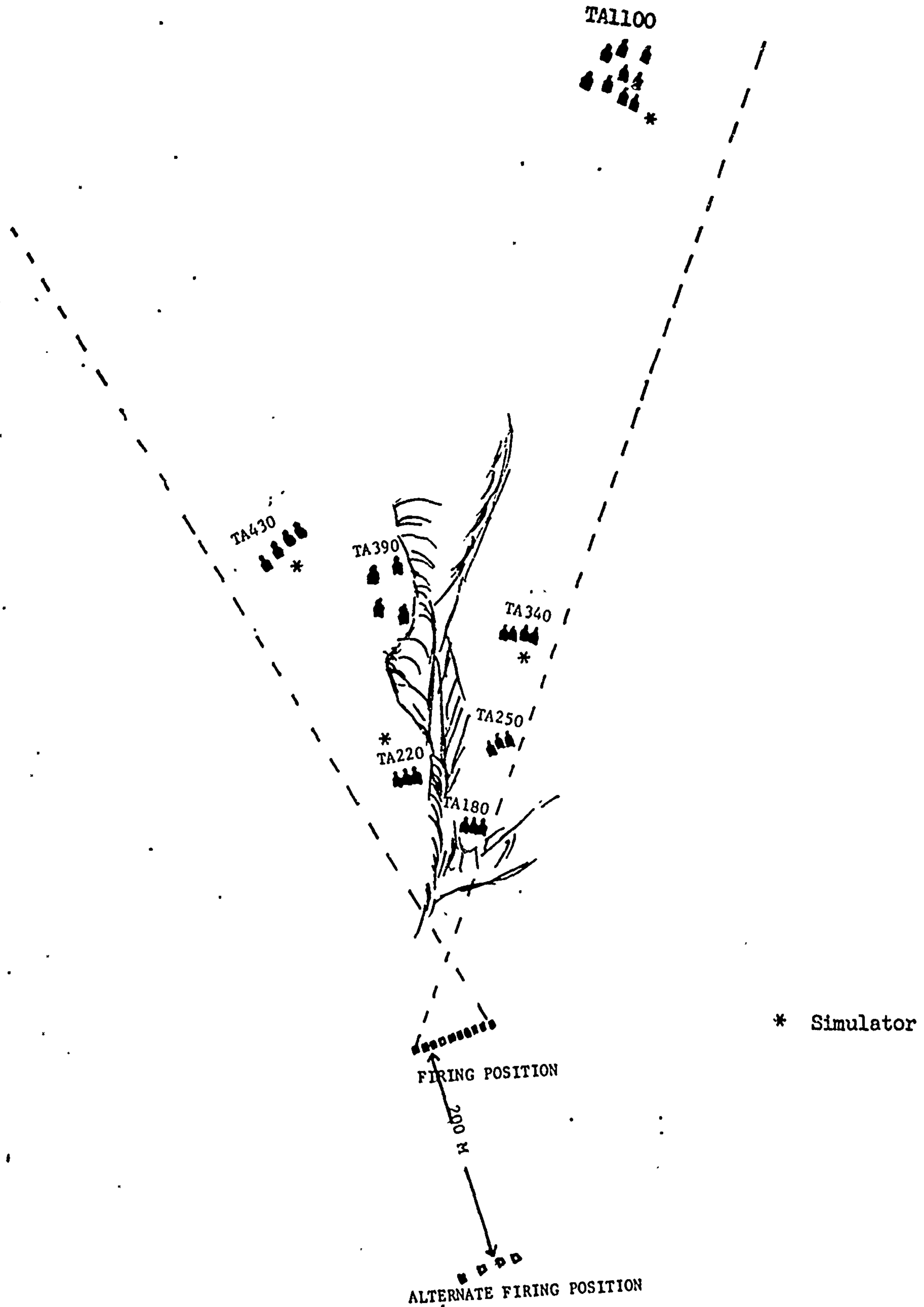
(c) Analytical Software - The library of analytical programs used in the analyses of small arms data is available and compatible with the machine gun weapon system. These programs include: Irregular Analysis of Variance - Two-way, t-test, multiple linear regression, and one-way analysis of variance.

(5) Range Requirements - Before machine guns can be adequately tested on the small arms test facilities, two additions must be made in addition to normal hardening to withstand heavy localized firing. These two additions are another firing position and an additional target array. These are described in the following section.

5. RANGE CONCEPTS

(a) Firing Positions - The defense test facility currently features 10 day firing positions and 4 night firing positions which can be selected for use in testing machine guns. One other position should be selected to the rear of the night positions to evaluate performance of the weapon system at intermediate ranges between 600 and 700 and long ranges of 1000 meters as required in specific subtests. This may be accomplished by adding an extension to one of the existing coax round count cables.

(b) Target Array - The current defense facility permits maximum engagement ranges of 430 meters from the day defense firing positions, 500 meters from the night positions and 600 to 700 meters (dependent on the specific location) from the new position. Evaluation of all ranges out to the maximum effective range of the weapon system is required and, hence, an additional long-range array is needed. The array should be located 800 meters from the day firing positions. This will permit ranges of 870 meters from the night positions and approximately 1070 from the new position. This array will provide the needed hit probability data to prepare accuracy estimates over the entire spectrum of engagement ranges. Figure 2 is given as a range configuration. Specific requirements for these additional targets appear below.




LMG TEST FACILITY CONFIGURATION

Figure 2

(c) Technical Data Package (TDP) for Target Array 800. It is proposed to utilize the existing defense range cable from the Control Distribution Center No. 3 to the van site. Installation of additional cable from Distribution Center No. 3 to the target area (approximately 1500 feet) will be required.

The attached map, Figure 2, shows the location of the additional target array. The TDP for this installation appears in Appendix III.

## 6. TEST CONCEPTS

Test methods and concepts for the evaluation of machine guns do not differ markedly from those required for rifle testing. The test facility modifications described above are adequate for testing the various capabilities of the machine gun. Subtests designed to evaluate the various capabilities of machine gun weapon systems are described in Appendix II. The next task is to insure that the physical conditions under which the subtests are performed are realistic and that recommended scheduling, weapon assignment, and training concepts are understood. The analytical plan is described in Appendix II. The remaining and most important task is to insure that the test is conducted according to the experimental design. Any deviations from the design due to problems with target scoring systems, launcher grenadiers, or weapons should be systematically recorded to insure that data intended for one cell of the experimental design does not mistakenly go into another cell compromizing the entire test. The initial analysis should be directed toward the objective of the service test, although the data base may, at a better time, be extremely useful for evaluating other methodological problems. Such knowledge can contribute to the problem of estimating sample sizes for future tests, optimizing target presentation scenarios, determining optimum burst sizes, the value of an assistant gunner, and possibly for weighting measures of effectiveness. Each set of service test data offer opportunities for continued improvement in test methodology.

VOLUME III

APPENDIX I

Infantry Machine Gun
Methodology Review

Appendix I

AD______________

USATECOM PROJECT NO 8-5-0070-01

USAIB PROJECT NO 3091

# INFANTRY WEAPONS TEST METHODOLOGY STUDY

## INFANTRY MACHINE GUN METHODOLOGY REVIEW

FINAL REPORT

BY

MAJOR JOHN D. JACKSON

SEPTEMBER 1970

UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

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ABSTRACT

The Infantry Weapons Test Methodology Study. The Infantry Weapons Test Methodology Study is a 5-year contractor-supported effort to develop new measures and techniques of measuring the performance of competing Infantry rifles, indirect-fire weapons and antitank weapons. To supplement the contractor effort and particularly to establish the military requirement, i.e., what should be measured, four methodology reviews were initiated. (A machine gun study was added to the three first mentioned.) The purpose of these four reviews is to determine through the consideration of Infantry combat actions and the resulting characteristic individual weapon performance or actions, valid measurements which will permit discriminations to be made between candidate weapons systems in the four categories. If the collection of these measurements requires sophisticated instrumentation or special firing facilities, they should be designed and constructed, and the validity of the measurements verified by testing.

The Infantry Machine Gun Review. The initial approach taken was that of (1) identifying all of the combat actions performed by Infantry combat units in which machine guns are employed; and (2) listing the various critical tasks normally accomplished by the individual/crew weapon combination when executing the combat actions. Certain special characteristics of the machine gun were also considered; these included such things as rates of fire, characteristics of fire, and tactical employment, all of which exert influence on the performance of the critical tasks and the combat actions. The analysis of these influencing factors enabled categories of effectiveness such as accuracy, sustainability, responsiveness, reliability and stability to be defined in terms of measurable parameters which are meaningfully related to a combat situation. Once defined, these parameters were further studied and developed into measures of effectiveness (MOE). Further analysis of the combat actions and the MOE revealed that due to terrain requirements, maneuver requirements, and the need for certain types of firing positions a specially instrumented machine gun facility should be constructed for the testing of candidate machine guns.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY INFANTRY BOARD
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INFANTRY MACHINE GUN METHODOLOGY REVIEW

1. PROBLEM.

a. To determine, through the consideration of Infantry combat actions and the resulting characteristic individual weapon performance or actions, the measurements, and the facilities upon which to obtain them, which will permit discriminations to be made between candidate machine gun systems. A complete method for discriminating between the candidate weapon systems is desired, to include findings, conclusions and recommendations.

b. To establish the relative value of the various measures.

2. ASSUMPTIONS.

a. For the purpose of this review a machine gun will be any military small arms, caliber .60 (15-mm) or below, capable of sustained fire, the power necessary for feeding, loading, locking, firing, extracting and ejecting being derived wholly from the energy generated by the explosion of the propellent charge. (For further clarification of the classification of the machine guns see Annex A, Appendix 1.)

b. Weapons tested on the developed ranges will continue to fire a solid projectile or missile (as opposed, for example, to a laser beam).

c. Current doctrine concerning the mission, employment and role of the Infantry machine gun/crew in combat will not materially change in the near future.

d. Sufficiently qualified test officers and scientific and engineering specialists are available within the Infantry Board to efficiently conduct such weapons systems evaluations and tests and reduce and analyze the collected data.

e. Current weapon development will continue to experience only small differences between competing machine gun systems.

3. FACTS BEARING ON THE PROBLEM.

a. Instrumented attack and quick-fire facilities have been constructed and used in the testing of military rifles. An instrumented defense facility is now being constructed and will be used to further test military rifles.

b. Small differences in weapon performance have been successfully measured on the existing instrumented attack and quick-fire facilities.

c. The service tests conducted by the Infantry Board are to be performed under simulated fire/combat conditions as prescribed by AR 70-10. The required realism is best obtained when tests do not have to be stopped or interrupted to obtain data.

d. An aim of the Infantry Board machine gun methodology review is to provide test procedures and techniques that will insure the selection of the most effective weapons and equipment for the Infantry soldier. The approach taken to achieve this aim was to cast these procedures in terms of the "real world of combat" environment, in which the candidate weapons and equipment will be required to function.

e. Prior to any review of machine guns it must be established that the machine gun is not a heavier or faster-firing automatic rifle. The machine gun is a military small arm, and as such has certain characteristics of its own. These include such things as rates of fire, characteristics of fire and tactical employment. (For more detail on these items see Annex A, Appendices 2-5.)

4. DISCUSSION

a. Initially a list of the various combat actions normally accomplished by Infantry combat units was prepared after researching all pertinent doctrinal and training literature (Annex I). As a result of this research 26 separate combat actions were identified and listed (Annex B).

b. Next, a list of the various critical tasks normally accomplished by the individual/crew when executing the combat actions listed in Annex B was prepared after further researching all of the pertinent doctrinal and training literature (Annex I). As a result of this further study 17 separate critical combat tasks were identified and listed (Annex C).

c. A concept table was prepared which presented for comparison and analysis the 26 combat actions and the 17 critical combat tasks

(Annex D). Further study of the table in which primary emphasis was placed on the actions of the individual/crew/weapon combination revealed that certain critical combat tasks are common to one or more combat actions. This allowed several reductions and/or combinations of the combat actions which reduced the original 26 to 6 (Annex E), one of which (fire and maneuver) was subdivided into a fire support portion and a maneuver portion, raising the total of combat actions considered for detailed analysis to 7.

d. A list of the various combat critical factors expressed in terms of the more commonly used words associated with military small arms effectiveness, and found in today's qualitative materiel requirements (QMR) was compiled. For example, a QMR on the project titled "Machine Gun, Lightweight, General Purpose (7.62-mm)" stated as follows:

"(1) <u>Purpose</u>

The purpose is to provide a machine gun capable of a large volume of sustained, accurate and effective small arms fire for all phases of ground combat, the primary target being personnel.

"(2) <u>Paramount Considerations</u>

(a) Sustained, accurate and effective automatic fire.

(b) Reliability and durability.

(c) Simplicity.

(d) Lightness of weight.

(e) Freedom from position disclosing effects."

The author of the above has stated a requirement and listed certain paramount considerations related to overall effectiveness of a candidate weapons system. However, further amplification of these considerations must be made in order to compare successfully the candidate weapons. This simple listing of broad considerations does not by itself provide realistic measures for the testing and evaluation of candidate weapons.

e. Examination of the paramount considerations or "categories of effectiveness" such as accuracy, sustainability, reliability, etc., revealed that these categories must be defined in terms of measureable parameters which meaningfully relate to a combat situation. Further, new categories must be established (responsiveness, stability) and old categories must be changed (lightness of weight to portability and compatibility; position-disclosing effects to signature effects). Once defined, these parameters were further studied and developed into measures of effectiveness (MOE) in order to measure effectively and thereby evaluate properly small differences between competing weapons systems. The MOE are discussed by category of effectiveness in Annex F.

f. The 26 combat actions were analyzed and it was found that each fell into one of three basic combat postures: attack, quick-fire, or defense; however, the quick-fire posture is more applicable to the vehicle mounted machine gun. This analysis was the first indicator of what type test facilities should be considered. Each combat action was again thoroughly studied, analyzed, and compared with regard to the categories of effectiveness to determine the appropriate discriminating MOE. In addition, one or more MOE were selected as most important in each category of effectiveness and so indicated by an asterisk. (Annex G, Appendices 1-7, Combat Action Flow Charts.)

g. In developing the comparison of MOE to combat actions, the three basic combat postures discussed in paragraph 4f, above, were again considered in structuring the Matrix, Annex H. This matrix is a compilation of all MOE and the seven combat actions used. The relation of MOE to combat action is shown, as is the level of instrumentation required to collect the data and the number of times each was collected. The last two columns reflect the most appropriate type range on which the data may be collected and the most suitable range available at the Infantry Board on which to collect the necessary data. (For further discussion of range facilities, see Appendix 3 to Annex H.)

h. Detailed analysis of Annex H, Matrix, with Appendices 1-3, reveals that of the 34 selected MOE, 30 can best be collected on an instrumented attack or defense type facility equally as well; three can best be collected on an instrumented quick-fire facility; and one, crew drill, does not need any type of instrumented facility. The USAIB attack and quick-fire facilities are not adquate for machine gun testing. Analysis of the three USAIB instrumented facilities either now in operation or under construction reveals that the instrumented defense range is the best available for machine gun testing. However, the best solution would be to build a special range on which to test candidate machine guns in all combat actions except combat in cities. Combat in cities will require a special type of instrumented facility for the thorough testing of candidate weapons. (See Appendix 4 to Annex H for details on this proposed range.)

i. Although the newly developed MOE provide the test officer a way of measuring small differences between candidate weapons systems, the results of these tests of the weapons systems show only those differences disclosed on the instrumented test facilities. These results must be coupled with current testing procedures such as done in maintenance evaluation, and troop safety for total service test evaluation.

j. Based on previous weapons evaluation experiments and project experience, it is felt that arbitrary weights cannot now be assigned for the MOE in an attempt to establish overall discriminators between competing weapons systems. However, a first rough step toward weighting has been taken by arithmetically computing the number of times an MOE can be collected and the number of times it is considered to be most important. As testing continues and more data are compiled, additional investigation should be made to develop a system for weighting the MOE.

5. CONCLUSIONS.

a. The 17 individual/crew combat tasks required in the accomplishment of the 26 combat actions overlap to the degree that permits a reduction from 26 to 7 combat actions studied. These can all be represented in the tactical environment present in attack, quick-fire, and defense situations.

b. The MOE under each combat action on the related facility will provide discriminators between candidate weapons systems in a combat environment.

c. When coupled with the data gathered from current test methodology, the discrimination between the MOE developed in this study will provide the basis for determining the better of two candidate weapons systems.

d. The present instrumented attack and quick-fire facilities, although completely adequate for testing candidate rifles, are not suited for machine gun testing.

e. The instrumented defense facility now under construction should, after the emplacement of additional targets at greater ranges, provide realistic combat-type situations wherein measurements are taken in real time through instrumentation and do not require interruption of testing to score target arrays.

f. For thorough testing of candidate machine gun systems, an instrumented range facility similar to that described in Appendix 4 to Annex H, and designed and constructed to withstand the heavy volumes of sustained fires characteristic of the machine gun, should be built. A separate Combat in Cities facility must be utilized for the testing of this representative combat action.

g. Weighting or assigning values to the various MOE depends upon the type machine gun system being evaluated and can be based at this stage only on frequency of measurement.

6. RECOMMENDATIONS.

a. That the Infantry Board construct an instrumented machine gun facility designed solely for the testing of machine guns.

b. That the developed MOE be accepted for inclusion in a future methodology test to be conducted on the newly constructed machine gun facility.

c. That investigation of Infantry machine gun methodology continue in order to collect data useful in assigning weighted values to the various MOE.

LIST OF ANNEXES

ANNEX A - GENERAL CHARACTERISTICS AND TACTICAL EMPLOYMENT OF THE MACHINE GUN WITH FIVE APPENDICES

ANNEX B - LIST OF COMBAT ACTIONS

ANNEX C - CRITICAL COMBAT TASKS

ANNEX D - TASK/ACTION CONCEPT TABLE

ANNEX E - REDUCTION OF COMBAT ACTIONS

ANNEX F - DISCUSSION OF MOE

ANNEX G - COMBAT FLOW CHARTS WITH SEVEN APPENDICES

ANNEX H - COMBAT ACTION MATRIX WITH FOUR APPENDICES

ANNEX I - REFERENCES

## ANNEX A

## GENERAL CHARACTERISTICS AND TACTICAL EMPLOYMENT OF THE MACHIN. GUN

1. GENERAL. It became apparent in the very early stages of the preparation of this review that certain uses of the machine gun must be considered, then dropped from further consideration as being too complex or too far removed from the ground combat role to be part of an Infantry combat action. It was further realized that the use of machine guns was governed by certain characteristics of fire such as rates and relationship to the target and to the ground, and that these characteristics would and should carry over into testing. Therefore, Annex A was written to list these characteristics and their effect upon the functioning and use of the machine gun.

2. USES OF THE MACHINE GUN NOT CONSIDERED IN DETAIL.

a. As part of an aerial platform. Machine guns of several types are found on various aerial platforms (army aircraft both fixed-winged and helicopter). Those weapons which are activated by the pilot through electrical means were considered as part of the aircraft armaments system of the particular aircraft in which it is mounted. Door guns on helicopters were also eliminated from further consideration as being impractical to evaluate on any instrumented facility now available or under construction here at the Infantry Board. This is due to such variables as aircraft speed, height, direction, angle of fire to target, bank of the aircraft, type of aiming systems, and methods of engagement.

b. In the antiaircraft role. Machine guns (primarily those in the heavy machine gun class) are frequently used in the antiaircraft role. Further consideration of the machine gun in the antiaircraft role was eliminated due to the methods of fire, the different types of sights used, rules of engagement, and the nonavailability of suitably aerially towed targets, tow planes and ranges at Fort Benning.

3. LIST OF APPENDICES TO ANNEX A.

a. Appendix 1 to Annex A - Classification of Machine Guns.

b. Appendix 2 to Annex A - Characteristics of Fire.

c. Appendix 3 to Annex A - Rates of Fire.

d. Appendix 4 to Annex A - Tactical Employment of the Machine Gun.

e. Appendix 5 to Annex A - Assault, Overhead and Position Defilade Fires.

APPENDIX 1 TO ANNEX A

CLASSIFICATION OF MACHINE GUNS

For further clarification, a discussion of the classification of machine guns by Jason E. Smith in his book "Small Arms of the World" is quoted:

* * * * * * *

"Classification of Machine Guns.

"The general term machine guns is loosely applied to a wide variety of automatic arms. In the interest of clarity, the general characteristics of the various classes are now given.

"Definitions.

"Light Machine Gun.

"This term customarily designates a weapon which can be fired automatically and which may or may not be furnished with a device to permit semiautomatic or single-shot fire. The light machine gun normally fires the same cartridge as the military shoulder rifle of the using nation, whether bolt action or semiautomatic. The normal weight of this weapon is from 15 to 30 pounds. It is customarily fitted with a buttstock like a standard rifle and is intended normally to be fired from shoulder support while in prone position. The front end is commonly supported when firing by a mount, usually a folding two-legged steel design.

"The light machine gun is capable of use by a single man under emergency conditions. Normally, however, it is operated by at least a two-man crew, the gunner and an ammunition carrier who feeds the weapon. Furthermore, it must be recognized that this form of weapon uses ammunition at such a high rate under combat conditions that it really requires additional support in the form of reserve ammunition carriers or providers.

"The feeding system may be any of the types found in other machine guns, though the most common types utilize detachable steel box magazines. Drum feeds are common in some European designs. notably German and Russian, but the belt feed is uncommon, normally being encountered only in designs where quick barrel change is a part of the design of the arm. This is because of the rapid overheating under continuous fire from a belt feed with its great ammunition carrying capacity in comparison to the box magazine patterns.

"Operation may be either gas or recoil. and in some occasional experimental design may even be blowback.

"Automatic Rifle c· Machine Rifle.

"This term is often used to designate an assault rifle or a light machine gun. It is a matter of national terminology. In general, the designation 'automatic rifle' or 'machine rifle' in the past was commonly employed with arms such as the Browning Automatic Rifle 'BAR' or its European equivalents. The designation automatic comes from the fact that the arm can fire in full automatic operation by merely holding back the trigger with the selector in the proper position. The characteristics under this name are the same as those given under the designation 'Light Machine Gun.' At times the name is also applied to the Post-World War II forms of shoulder rifles having full-auto switches -- the true 'automatic rifles.'

"Weapons classed as machine rifles and light machine guns have the advantage of very high mobility. This, together with their ease of handling by one man in an emergency make them the perfect weapon for frontline operations. Since the weight and bulk are low, these guns must be fired in bursts, and are not suitable for sustained firing except where extra barrels are readily available for interchange. Regardless of the firing rate, it is actually not practical to fire much more than 100 per minute from the light machine gun except in case of direst emergency.

"Medium Machine Gun.

"The 'medium machine gun' (commonly referred to merely as 'machine gun') uses the same rifle cartridge as the light machine gun.

"The medium machine gun of modern design weighs between 25 and 60 pounds. While it has a firing rate of 500 rounds per minute or more, in actual usage it normally will deliver a maximum of about 250 rounds per minute from belt feed. Clip or drum feeds holding fewer cartridges provide substantially lower fire volumes.

"Even when several interchangeable barrels are available, a gas-operated medium machine gun is seldom capable of sustained fire of more than 6,000 rounds per hour actually delivered. The water-cooled varieties on the other hand have been known to fire up to 15,000 rounds per hour, because of their more efficient but far bulkier and heavier cooling systems.

"The medium machine gun is normally mounted on a folding portable tripod. This arm also, of course, requires a gun crew to sustain it, or even to put it into action, since the minimum handling crew must be one man for the tripod, one the gun, and at least one for ammunition. Once the gun is fixed, of course, it can in emergency be operated by the firer alone.

"Because of its weight, cooling system, and stable mounting, the medium machine gun can be used effectively at ranges three to four times greater than is possible with the light machine gun.

"All the operating systems used in the light machine gun are also applicable to the medium machine gun.

"<u>General Purpose Machine Gun</u>.

"Sometimes called a 'dual purpose machine.' These are weapons which are intended to be used on bipods as light machine guns and on tripods as medium (heavy rifle caliber) machine guns. They are normally belt-fed, but frequently use small ammunition boxes attached to the gun when used in the light machine gun role. The US M60, the French M52, the FN type MAG, and the German M42 fall in this category.

"<u>Heavy Machine Gun</u>.

"In general the characteristics are those of the light machine gun except that the weight of all components is greatly increased, as is their size also. The term heavy machine gun is correctly applied today only to cartridges .50 caliber and larger. In general, these arms are merely scaled up models of the equivalent medium machine gun pattern, as in the case of our .50 caliber Browning. Such guns today play a considerable part in various forms of motorized equipment carrying machine guns and are used to some extent for low antiaircraft fire, often in multiples. Since the cartridges they use are too powerful for normal use in standard rifle pattern weapons, and since their mechanical and design characteristics are but minor modifications of the medium machine guns, no further coverage of them is required here."

* * * * * * *

## APPENDIX 2 TO ANNEX A

## CHARACTERISTICS AND CLASSES OF FIRE

## (EXTRACTS FROM FM 23-67)

### Section II. FUNDAMENTALS

**68. Characteristics of Fire**

*a. Trajectory.* This is the path of the projectile in its flight. It is almost flat at ranges of 300 meters or less. At ranges beyond 300 meters the trajectory is curved and the curve becomes greater as the range increases (fig. 70).

*b. Maximum Ordinate.* This is the highest point which the trajectory reaches above an imaginary line from the muzzle of the gun to the base of the target. It always occurs at a point approximately two-thirds of the distance from the gun to the target. The maximum ordinate increases as the range increases (fig. 70).

*c. Cone of Fire.* When several rounds are fired in a burst from a machinegun, each projectile takes a slightly different trajectory. This is caused by vibrations of the gun and variations in ammunition and atmospheric conditions. The pattern formed by the multiple trajectories of each burst of fire is called the *cone of fire.* (fig. 71).

*d. Beaten Zone and Center of Impact.* The area where the cone of fire strikes the ground or the target is called the beaten zone (figs. 71 and 72).

(1) The size and shape of the beaten zone changes when the range to the target changes and when the gun is fired into different types of terrain. On uniformly sloping or level terrain, the beaten zone is elliptical (long and narrow) in shape (fig. 72). As the range

(H = MAXIMUM ORDINATE—HIGHEST POINT OF TRAJECTORY)

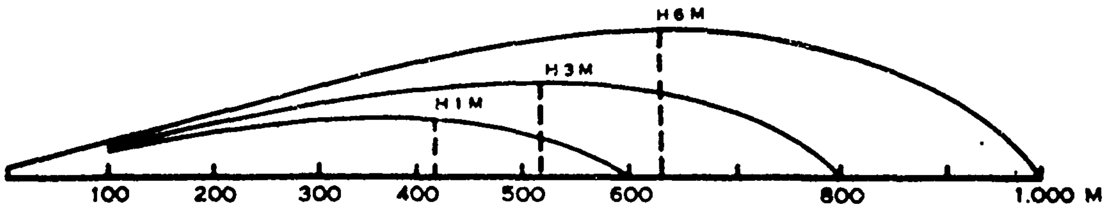

*Figure 70. Trajectory and maximum ordinate.*

to the target increases beyond 500 meters, the beaten zone will become shorter and wider. When fires are delivered into falling ground, the beaten zone will become longer. When fires are delivered into rising ground, the beaten zone will become shorter. The terrain has no appreciable effect on the width of the beaten zone.

(2) The center of the beaten zone is called the *center of impact.* The center of impact will coincide with the line of aim if the weapon is properly zeroed.

*c. Danger Space.* This is the space between the gun and the target where the trajectory does not rise above the average height of a standing soldier (1.8 meters). This includes the area encompassed by the beaten zone.

(1) When a machinegun (on its bipod or tripod mount) is fired over level or uniformly sloping terrain at a target less than 700 meters away, the trajectory will not rise above the average height of a standing soldier (fig. 73).

(2) When firing at targets at ranges greater than 700 meters, the trajectory will rise above the height of an average standing soldier; therefore, not all the distance between the gunner and the target is danger space (fig. 73).

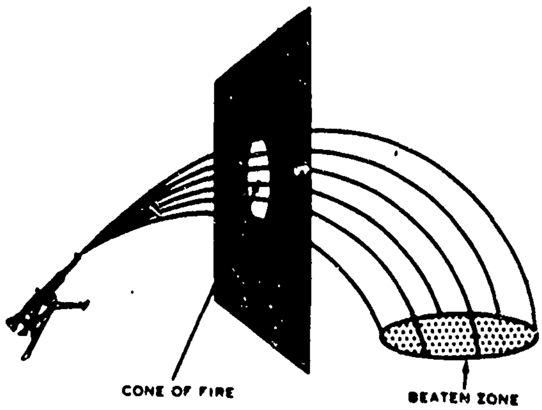

*Figure 71. Cone of fire and beaten zone.*

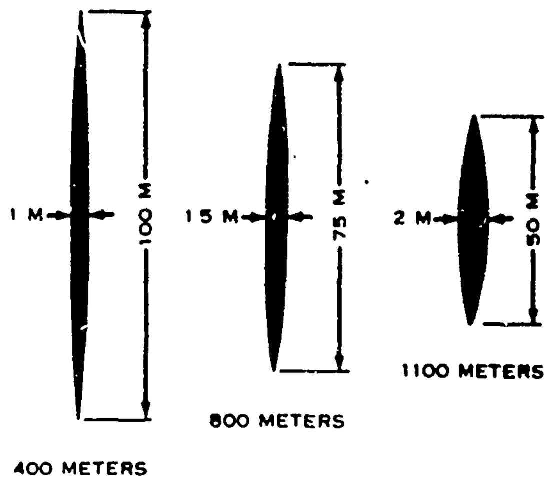

*Figure 72. Size and shape of beaten zones.*

## 69. Classes of Fire

Machinegun fire is classified with respect to the ground, target, and gun.

*a.* Fire with respect to the ground (fig. 74) is—

(1) *Grazing* when the center of the cone of fire does not rise above one meter. When firing over level or uniformly sloping terrain, a maximum of 600 meters of grazing fire can be obtained.

(2) *Plunging* when the danger space is practically confined to the beaten zone. Plunging fire occurs when firing at long ranges, when firing from high ground to low ground, and when firing into abruptly rising ground.

*b.* Fire with respect to the target (fig. 75) is—

(1) *Frontal* when the long axis of the beaten zone is at a right angle to the front of the target.

(2) *Flanking* when delivered against the flank of a target.

(3) *Oblique* when the long axis of the beaten zone is at an angle other than a right angle to the target.

(4) *Enfilade* when the long axis of the beaten zone coincides or nearly coincides with the long axis of the target. This type of fire is either frontal or flanking and is the most desirable type of fire with respect to a target because it makes maximum use of the beaten zone.

*c.* There are six types of fire classified with respect to the gun: fixed, traversing, searching, traversing and searching, swinging traverse, and free gun (fig. 76). Swinging traverse and

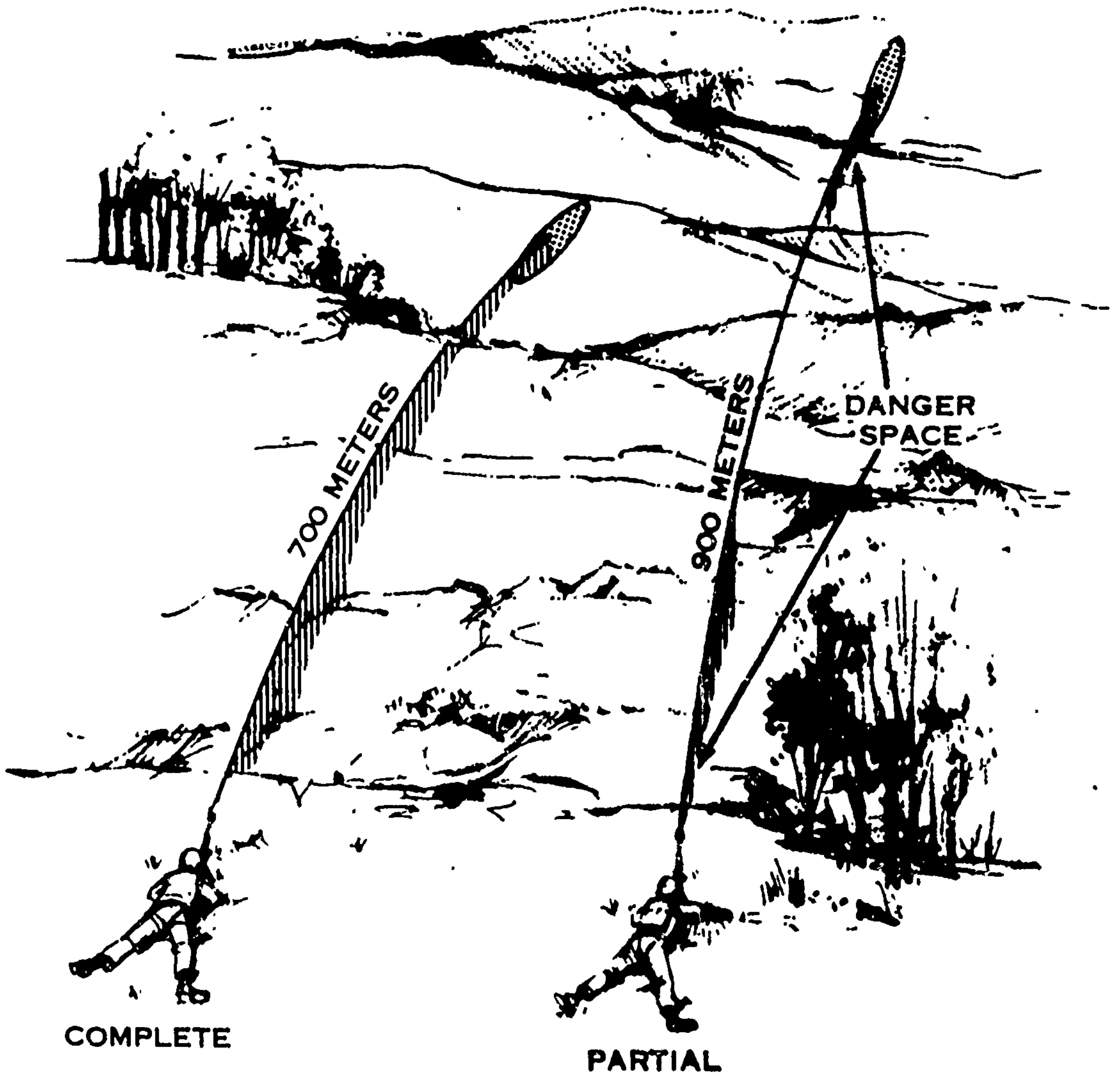


*Figure 73. Danger space.*

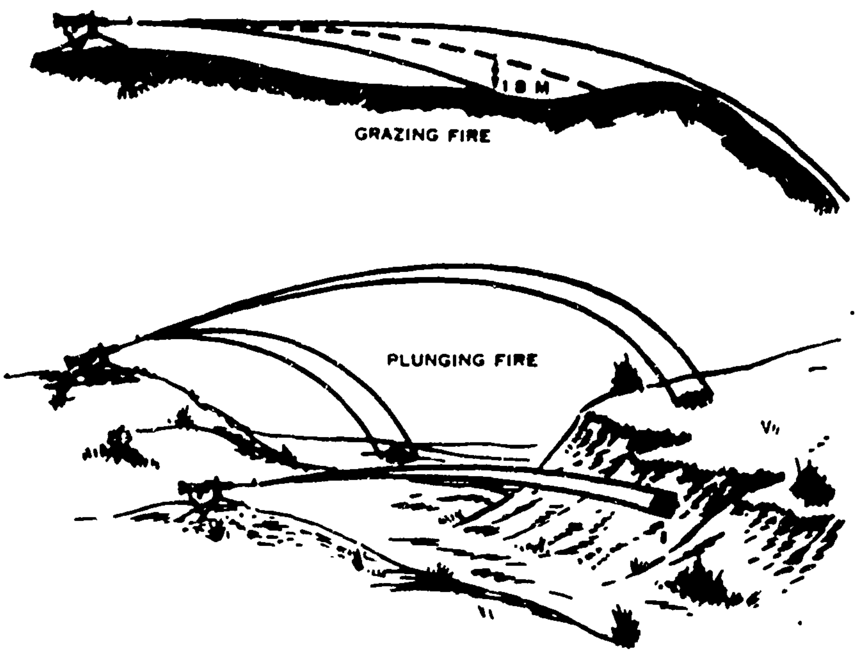


*Figure 74. Plunging and grazing fire.*

free gun fire cannot be delivered with the bipod mounted gun. With the vehicular mounted gun, swinging traverse fire cannot be delivered. The other types of fire can be delivered with either the bipod, tripod, or vehicular mounted gun.

(1) Fire with respect to the gun is—

(a) *Fixed* when delivered against targets which require a single aiming point.

(b) *Traversing* when distributed in width by successive changes in direction. With the tripod mounted gun, the changes are made in 4- to 6-mil increments on the traversing handwheel. To insure adequate target coverage, a burst is fired after each direction change.

(c) *Searching* when distributed in depth by successive changes in elevation. When firing the tripod mounted gun over level or uniformly sloping ground, the changes are made on the elevating handwheel in 2-mil increments. When fires are delivered into rising ground, more than two mils of change are required. When fires are delivered into falling ground, less than two mils of change are required. Gunners learn the amount of change to apply through experience. To insure adequate target coverage, a burst is fired after each elevation change.

(d) *Traversing and searching* when distributed in width and depth by successive changes in direction and elevation. With the tripod mounted gun, the changes in direction are made in 4- to 6-mil increments on the traversing handwheel. The amount of elevation change is determined by the slope of the terrain and the angle of the target. To insure adequate target coverage, a burst is fired after each *combined* change in direction and elevation.

(e) *Swinging traverse* when delivered against targets too wide to cover with the traversing handwheel and targets moving so rapidly across the gunner's front, that he cannot maintain effective fire while using the traversing handwheel. To deliver this type of fire, the gunner loosens the traversing slide lock lever to

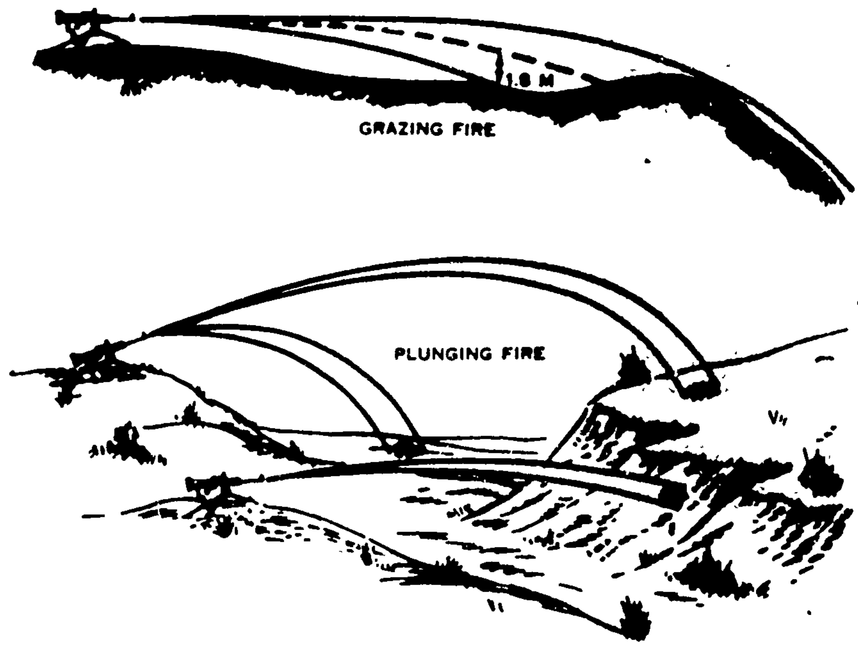


*Figure 74. Plunging and grazing fire.*

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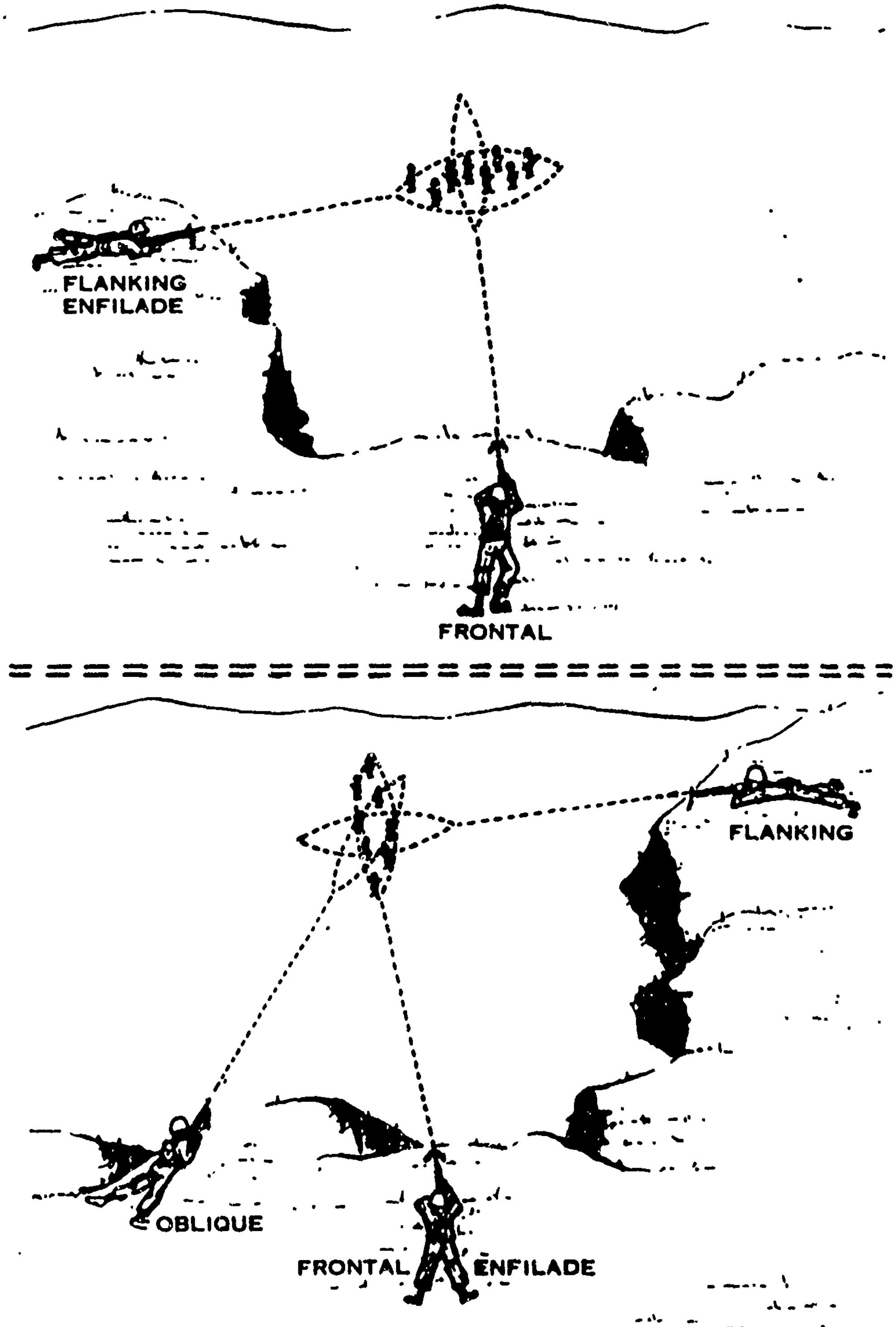



*Figure 75. Classes of fire with respect to the target.*

allow the traversing and elevating mechanism to slide freely on the traversing bar. Changes in direction are made by applying pressure to the rear of the gun. Minor changes in elevation are made by manipulating the elevating handwheel.

(f) *Free gun* when delivered from the tripod mount against targets requiring rapid, major changes in direction and elevation which cannot be applied with the traversing and elevating mechanism, and when delivered from the vehicular mount against targets which cannot be adequately covered by selecting a series of aiming points. To deliver this type of fire from the tripod mount, the gunner loosens the traversing slide lock lever and lifts the traversing and elevating mechanism from the traversing bar to allow the gun to be moved freely in any direction. To deliver this type of fire from the vehicular mount, the gunner allows the weapon to rest freely on the mount. Changes in direction or elevation are made by applying pressure to the rear of the gun.

(2) With the bipod or vehicular mounted gun, fixed fire is delivered by firing a series of bursts at a single aiming point. To deliver traversing, searching, or traversing and searching fire with the bipod or vehicular mounted gun, the gunner selects a series of successive aiming points on the target and fires a succession of aimed bursts. To insure adequate target coverage, he observes the width and length of the beaten zone of the initial burst and selects each succeeding aiming point a sufficient distance from the previous burst to allow an overlap of the beaten zone.

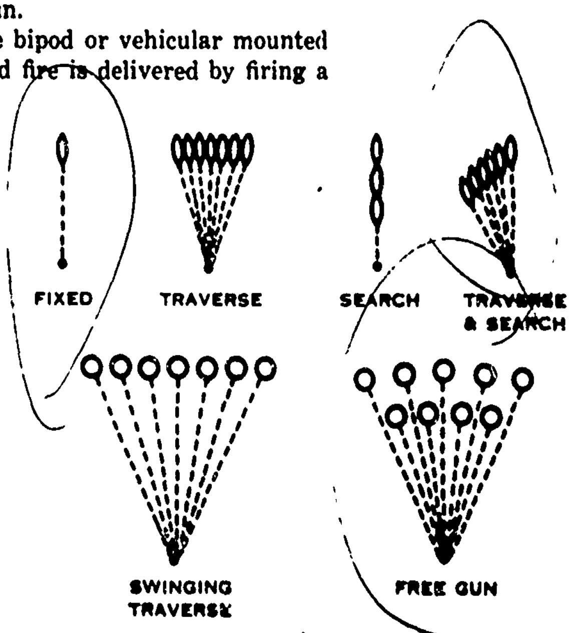



*Figure 76. Classes of fire with respect to the gun.*

## APPENDIX 3 TO ANNEX A

## RATES OF FIRE

1. There are three rates of fire— the cyclic, the rapid, and the sustained rate. Rates of fire are established for the machinegun in order to obtain maximum effectiveness for ammunition expended and control purposes, as well as to indicate to the gunner when a barrel change is necessary.

a. The cyclic rate of fire represents the maximum amount of ammunition that can be expended by a weapon in one minute.

(1) This is approximately 550 rounds for the M60 machinegun.

(2) This rate is in effect when the gunner holds the trigger to the rear as ammunition is continuously fed into the weapon.

(3) When firing at the cyclic rate the barrel should be changed once every minute.

b. The sustained rate of fire is in effect when the gunner fires approximately 100 rounds per minute in 6-9-round bursts.

(1) This results in about 13 bursts per minute allowing for a pause of 3-4 seconds between bursts.

(2) When firing at the sustained rate the barrel should be changed every ten minutes.

c. The rapid rate of fire, which is the preferred rate of fire, exists when the gunner fires approximately 200 rounds per minute, again in 6-9-round burst.

(1) This results in about 26 bursts per minute with a 1-2-second pause between each burst.

(2) When firing at the rapid rate the barrel should be changed every two minutes.

d. Therefore the rate of fire depends on the pause between bursts.

(1) For the cyclic rate there is one continuous burst for one minute pausing only for a barrel change.

(2) For the sustained and rapid rates of fire the number of rounds expended in each burst is the same, however the pause between each burst is longer for the sustained rate than it is for the rapid rate.

Properly employed in the supporting role or with the assaulting element, the machinegun provides the riflemen in offensive operations with a heavy volume of close, accurate, and continuous fire.

2. Advantages and Disadvantages of Each Rate of Fire.

a. Each rate of fire has its advantages and disadvantages.

(1) The cyclic rate does produce the greatest amount of firepower, however this advantage is more than offset by the disadvantages produced by the quick expenditure of ammunition, the overheating of the barrel requiring a barrel change every minute, and a definite decrease in accuracy.

(2) This rate is seldom used.

(3) The only time that it would be used would be to engage aerial targets or to fire a sector of graze during a mass enemy assault.

b. The sustained rate has the advantage of using the least amount of ammunition and requiring the least number of barrel changes over a given period of time.

(1) This rate does not take advantage of the rapid firepower capabilities for which the machinegun was designed.

(2) This rate should be used in combat situations where ammunition supplies are critical.

c. The ideal rate of fire is the rapid rate.

(1) Ground targets should be initially engaged using the rapid rate of fire in order to attain fire superiority.

(2) After fire superiority has been attained, and only after it has been attained, could the rate possibly be reduced.

d. The six to nine round burst has been proven to be the optimum number of rounds which can be fired with accuracy by a gunner.

APPENDIX 4 TO ANNEX A

EXTRACTS FROM FM 23-67

# CHAPTER 9

# TACTICAL EMPLOYMENT OF THE M60 MACHINEGUN

## Section I. INTRODUCTION

### 114. General

Before the machineguns of a rifle platoon can be effectively employed, the terms and techniques for applying fire during periods of good and limited visibility as discussed in chapters 7 and 8 must be understood. Because of the number and diversity of missions assigned the weapons squad in tactical operations and the resulting difficulty of direct control by the squad leader, individual initiative and actions are required of members of the machinegun crews.

### 115. Scope

This chapter amplifies the doctrine contained in FM 7-15 to assist the instructor, platoon leader, squad leader, and the individual member of gun crews in effectively employing the M60 machinegun. This chapter includes—

*a.* Definitions and discussions of the terms frequently used in defensive and offensive operations as they apply to the M60 machinegun.

*b.* Fundamentals of employing the M60 machineguns in offensive and defensive operations.

## Section II. DEFINITIONS

### 116. General

This section defines and discusses terms frequently used in offensive and defensive operations. These terms must be commonly understood by all members of the rifle platoon prior to any discussion of tactical employment.

### 117. Defense Terms

*a. Primary Position.* That location on the ground which provides the best observation and fields of fire to accomplish the assigned mission.

*b. Alternate Position.* The next best position(s) from which the assigned mission (the same mission(s) assigned for the primary position) can be accomplished.

*c. Supplementary Position.* A position assigned for defending in a direction that cannot be covered from the primary position.

*d. Forward Edge of the Battle Area* (FEBA). The FEBA is the line formed by the forward defensive positions (fig. 120).

*e. Frontage.* Space from side to side covered by a unit in combat.

*f. Combat Outpost Line* (COPL). The COPL is a line formed by the security echelon of a unit which denies the enemy close ground observation of the unit position (fig. 120).

*g. Outguard.* One of the elements of the unit deployed on the COPL. An outguard may vary in size from half a squad to a reinforced squad. Outguards are positioned on or near the topographical crest of terrain features in order to obtain maximum observation and long range fires. To insure that the combat outpost can provide early warning of the advance of the enemy, outguards are located where they can obtain overlapping sectors of observation. Adjacent outguards should be capable of mutual fire support and should be located within visual distance of one another (fig. 120).

*h. Long-Range Fires.* Fires employed against the enemy as soon as he comes within effective range.

*i. Close Defensive Fires.* Fires employed against the enemy that subject him to an increasingly heavier volume of fire as he approaches the battle area.

*j. Final Protective Fires.* Fires immediately in front of the battle area which are used to break up the enemy assault. During final protective fires machineguns fire their final protective lines.

### 118. Attack Terms

*a. Fire and Maneuver.* Fire and maneuver consists of an element(s) establishing a base of fire to cover the movement of another element(s) while it maneuvers to close with and destroy or capture the enemy.

*b. Fire and Movement.* When the maneuver element(s) meets effective enemy opposition and can no longer advance under the cover of supporting fires, it employs fire and movement. Fire and movement consists of one element providing close fire support while another element advances toward the enemy. This procedure may be repeated as often as necessary until one or both of the attacking elements are in position to assault the enemy position. Depending upon the situation, it may be necessary to conduct the assault on the objective by the application of fire and movement from the time the assault starts until the objective is completely overrun.

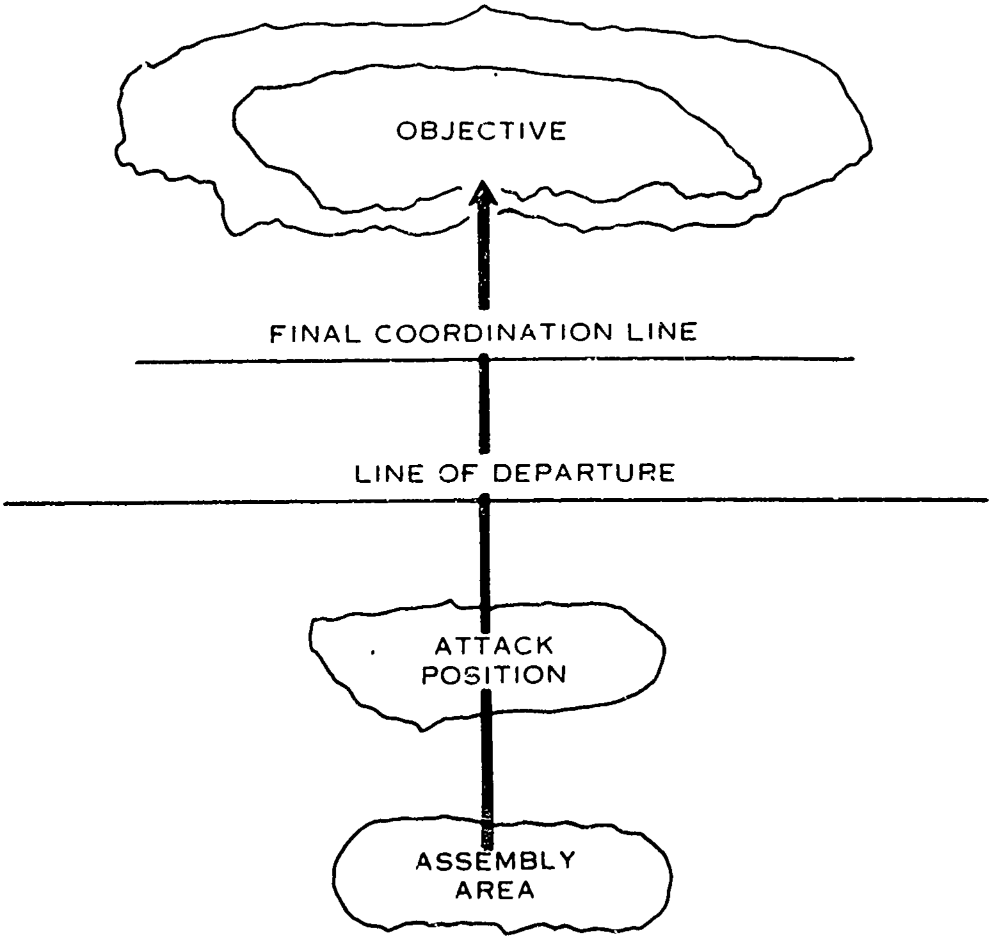



*Figure 121. Control measures used during a daylight attack*

*c. Displacement by Crews.* Displacement of one (or more) machinegun crew(s) to a new position(s), the other crew(s) remaining in position firing, or prepared to fire, on a given target or area. Where necessary, the movement can be continued by bounds or echeloned bounds.

*d. Assembly Area.* The area in which a unit prepares for an offensive or defensive operation. Units are suitably dispersed, and while orders are issued, reconnaissances conducted, and resupply and maintenance accomplished, the command is disposed for defense and the security required by the situation maintained. Under these conditions, machineguns will often occupy firing positions. In an attack situation this area is usually company size and located within one hour's movement time of the line of departure (fig. 121).

*e. Attack Position.* This is the last concealed and covered position short of the line of departure where platoons deploy in the attack formation and make final coordination. The platoon will halt in the attack position only when final preparations cannot be completed in the assembly area or on the move, or when ordered by the company commander (fig. 121).

*f. Line of Departure* (LD). This is a line designated by the company commanders to coordinate the beginning of the attack and is usually an easily recognizable terrain feature, such as a stream or road, running perpendicular to the direction of attack (fig. 121).

*g. Final Coordination Line.* This is a line used to coordinate the lifting and shifting of supporting fires and the final deployment of the maneuver element in preparation for conducting an assault against an enemy position. It

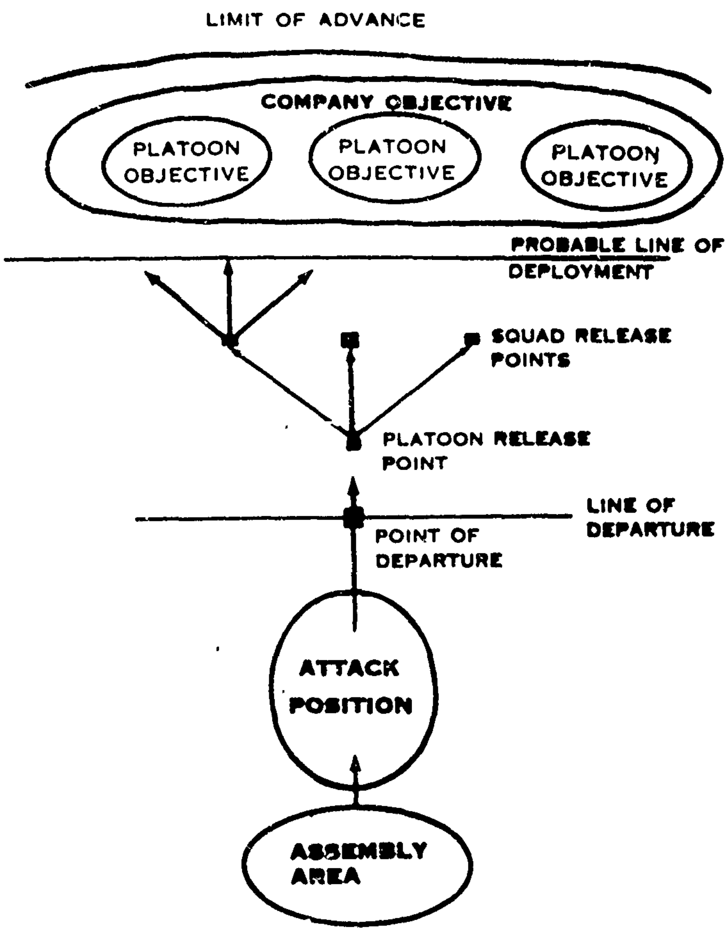



*Figure 122. Control measures used during a night attack.*

is located as close to the enemy position on the objective as attacking troops can move before becoming dangerously exposed to friendly supporting fire.

*h. Objective.* This is a designated locality or terrain feature to be captured or reached during the attack or during movement (fig. 121).

*i. Reorganization on the Objective.* Reorganizing the attacking unit as necessary by replacing casualties, reassigning men if necessary, ammunition resupply or redistribution as necessary, and performing any other actions necessary to prepare the unit for further action.

*j. Consolidation on the Objective.* Organizing and strengthening a newly captured position to defend against an enemy counterattack.

*k. Points of Departure.* Specific locations at which designated units will cross the line of departure in a night attack (fig. 122).

*l. Release Points* (RP). A clearly defined point on the route where units are turned over to the control of their respective leaders (fig. 122).

*m. Probable Line of Deployment.* A line previously selected on the ground where attacking units deploy prior to beginning an assault during periods of limited visibility. It is located as close to the objective as possible without revealing the presence of the assaulting element (fig. 122).

## Section III. EMPLOYMENT OF THE M60 MACHINEGUNS OF THE RIFLE PLATOON IN THE DEFENSE

### 119. General

*a.* This section provides guidance for the platoon leader, the weapons squad leader, and the machinegun crew in employing M60 machineguns in defensive operations. The provisions are applicable to the rifle platoon of the infantry, airborne infantry, and mechanized infantry battalions.

*b.* The mission of the platoon in the defense is to repel the enemy's assault by fire and close combat. Rifle platoon machineguns possess combat characteristics which are of major importance in the defense. Machineguns can—

(1) Produce a heavy volume of direct fire.
(2) Deliver grazing fire out to 600 meters.
(3) Produce sustained fire for a prolonged period.
(4) Effectively engage targets at ranges out to 1100 meters.
(5) Deliver accurate predetermined fires based upon direction and elevation data.
(6) Deliver overhead fire.

*c.* To exploit these characteristics, machineguns located along the forward edge of the battle area provide maximum fire support by participating in the delivery of long range fires, close defensive fires, and final protective fires.

### 120. Missions

Selection of a machinegun's primary position is primarily dependent upon its planned principal mission(s). Principal missions for a machinegun, in addition to a sector of fire which is habitually assigned, are: a final protective line, a principal direction of fire day, and a principal direction of fire night.

*a. Sectors of Fire.* Machinegunners of the rifle platoon are assigned primary and secondary sectors of fire as appropriate. Within these sectors the gunner may be assigned a final protective line if terrain permits, a principal direction of fire day, and principal direction of fire night.

(1) *Primary sector.* When possible, the tripod mounted M60 machinegun is employed to cover the primary sector. The tripod mount permits accurate, controlled fire to the maximum effective range of the gun. Inherent in the mount is the important capability of selective prearranged fires, as well as reduction in the adverse effects of personnel fatigue. This mount has approximately 875 mils of controlled traverse. The primary sector is normally assigned to take advantage of the maximum extent of this controlled traverse and is located close to the units on the FEBA (fig. 120).

(2) *Secondary sector.* The secondary sector of fire may be as wide as the terrain and situation permit (fig. 120). Within the secondary sector of fire, a gunner

selects target areas of tactical significance. The gunner may engage these areas and other targets appearing in this sector, providing that no vital targets are visible in his principal direction of fire. Targets in the secondary sector are engaged using free gun, by removing the gun from its tripod mount and using the bipod mount, or by using field expedients as discussed in, paragraph 111.

*b. Final Protective Lines.* A well chosen final protective line constitutes the best use of machinegun fire during periods of limited visibility. Although 600 meters of effective grazing fire can be achieved against the average standing soldier over level or uniformly sloping terrain, grazing fire will seldom be obtained beyond 400 meters. Since terrain will normally restrict grazing fire to less than 400 meters, every attempt should be made to obtain knee high fire (one meter high maximum). Grazing fire obtained on a final protective line should be flanking enfilade.

*c. Principal Direction of Fire Day and Principal Direction of Fire Night.* A principal direction of fire day is assigned to be covered during periods of good visibility, and a principal direction of fire night is assigned to be covered during periods of limited visibility. *The gun is always laid on the principal direction of fire day during periods of good visibility and on the principal direction of fire night during periods of limited visibility, unless other targets are being engaged.* Visible targets appearing in the principal direction of fire day or principal direction of fire night take priority over targets appearing elsewhere in the sector.

## 121. Selection of Positions

*a.* In the defense, the machineguns of the rifle platoon may be employed singly or in pairs and assigned principal missions discussed in paragraph 120. The method of employment depends on the platoon frontage and the type of terrain in the platoon area. The advantages afforded by employing machineguns in pairs are relative ease of control and resupply. When the guns are employed in pairs, they are normally assigned different primary and secondary sectors (fig. 120).

*b.* Machineguns should be located to receive incidental protection from adjacent rifle squads.

*c.* Until the platoon is prepared to defend itself, machinegun fire across its position is vital. Where flanking fire from the selected primary position is feasible, the guns are emplaced in temporary positions adjacent to these positions. Many times temporary positions somewhat forward of the FEBA must be occupied to obtain effective fire. Such exposed positions should be promptly withdrawn once the defense is organized. Minimum personnel of the gun crews man these temporary positions to conserve personnel for concurrent work on the primary position(s).

*d.* In some situations a machinegun crew can exploit all of the characteristics of the weapon discussed in paragraph 119*b* from one position during periods of both good and limited visibility. In many instances, however, it will be necessary to select a minimum of two positions. A primary position is selected which takes advantage of these characteristics during periods of good visibility and periods of limited visibility caused by fog, rain, snow, or smoke. A secondary position is selected which gives the machinegun the desired capability during hours of darkness. Thus, when selecting machinegun defensive positions—

(1) First, select the weapon's principal mission(s), considering the terrain, by assigning a primary and secondary sector, and a possible final protective line, principal direction of fire day, and principal direction of fire night. In order of priority, the following should be considered in regard to the terrain in selecting the weapon's principal mission(s).

(*a*) During periods of good visibility.

*1.* Good fields of fire and observation over areas which will enable the machinegunner to deliver long range fires and close defensive fires.

*2.* Grazing fire along a final protective line.

*3.* Cover and concealment.

(*b*) *During periods of limited visibility.*

*1.* Grazing fire along a final protective line.

*2.* Good fields of fire, and observation when visibility permits, over areas which will enable the machinegunners to deliver close defensive fires.

*3.* Capability of delivering long range preplanned fires.

4. Cover and concealment.

(2) Decide whether each gun of the section should have the same or different principal missions.

(3) Next, select the sector(s) of fire, considering the 875 mils of controlled traverse limitation of the tripod, the platoon defense area, and the desirability of a favorable location of the principal mission of each gun within its sector of fire.

(4) Based upon the factors listed in (1), (2), and (3) above, locate the general area of each weapon's primary position considering local cover and rearward routes of communication available.

(5) Decide whether a temporary position(s) must be occupied while the defense is being organized. If so, whether the platoon front can be covered with grazing fire from a single section position on one flank or whether separate temporary positions are required. Proximity to the primary position(s) is desirable, but the effectiveness of fire should not be sacrificed for it.

## 122. Preparation for the Defense

*a.* The machineguns of the weapons squad are a part of the platoon's organic fire support. The platoon leader assigns the missions and general firing positions for these weapons. He will assign alternate and supplementary positions as necessary.

*b.* The weapons squad leader normally accompanies the platoon leader on his reconnaissance to make recommendations concerning positions for the weapons squad.

*c.* Upon arrival of the platoon in the defense area and the completion of the platoon defense order, the weapons squad leader—

(1) Makes any further detailed reconnaissance required for specific gun positions.

(2) Issues his order to the gun crews from a location(s) which best enables him to point out specific areas within the platoon area.

(3) Outlines the work priorities included in the platoon order as they affect the gun crews.

(4) Supervises execution of the order.

(5) Coordinates essential details with adjacent rifle squads and other crew-served weapons whose fire missions require such coordination.

*d.* Guns are emplaced as directed by the leader for immediate assumption of their mission(s). The squad leader closely supervises the preparation of the positions.

*e.* Range cards are prepared for gun positions immediately upon arrival of the gunners regardless of their anticipated length of stay (para. 112 and 113). In adjusting fire to confirm elevation data for range cards, gunners should use single rounds. Field expedients may be used to aid gunners in laying their weapons to cover areas of tactical significance (para. 111*b*).

*f.* Preparation and improvement of gun positions are continuous. As long as the area is occupied, improvements are made to strengthen the defensive posture of the guns. The following work is accomplished in the priority listed, if time permits.

(1) Clear fields of fire and maintain camouflage and concealment concurrently with work.

(2) Prepare a hasty position (emergency emplacement).

(3) Prepare a horseshoe position for the gun with proper gun platform depth to insure maximum cover for the weapon, commensurate with the mission(s) (fig. 123).

(4) Prepare other positions for crew members.

(5) Minimize dust caused by the weapon's muzzle blast by dampening the ground or by placing wet sandbags forward of the muzzle.

(6) Construct overhead protection.

(7) Prepare a bunker.

*b.* At ranges of 1,000 meters or less, the enemy is likely to be in formations or occupying areas which are considered desirable machinegun targets. As the enemy approaches the defensive positions, the machinegunners engage targets within their sectors of fire using techniques discussed in chapter 7. *Consideration should be given to conducting the long-range harassing fires from temporary positions to avoid giving away primary positions.* In the absence of targets in a gunner's principal direction of fire, he may engage lucrative targets anywhere within his primary and secondary sectors. As the enemy continues to approach the platoon area, he is brought under an increasing volume of machinegun fire.

*c.* As the effectiveness of the close defensive fires forces the enemy to present less lucrative targets and utilize cover, machinegunners decrease their volume of fire and engage only targets which pose threats to the platoon defensive area.

*d.* If the enemy continues to advance through the close defensive fires and starts his assault, the platoon leader calls for his final protective fires. When final protective fires are called for the machinegunners will fire their final protective lines, if assigned. If final protective lines are not assigned, machinegunners fire their sectors of graze.

## 124. Conduct of the Defense of the Forward Rifle Platoon During Periods of Limited Visibility

The conduct of the defense during periods of limited visibility differs from that discussed in paragraph 123. The conduct of the defense during periods of limited visibility begins for the machinegunners of the rifle platoon when reports indicate that an attack is imminent or when the enemy can be observed.

*a.* Predetermined fires are used extensively to engage suspected enemy locations at long ranges and at midranges. When enemy locations are reported by listening posts or surveillance devices, these areas may be brought under fire by predetermined fire data as discussed in paragraphs 108 through 111.

*b.* Targets made visible by artificial illumination are engaged using techniques discussed in paragraphs 101 through 107. Firing techniques for engaging targets made visible by artificial illumination differ from those used during periods of good visibility. When artificial illumination is used (organic or attached), the location of the bursting area of flares or areas of illumination by other illuminating devices should be controlled from the forward rifle platoon area. Well directed close-in illumination (600 meters or less) enables machinegunners to place effective fire on visible targets.

## 125. Reserve Platoon in the Defense

*a.* The reserve platoon is positioned in the rear of the forward platoon to provide depth to the company defensive area. The platoon is located on the best defensive terrain from which it can accomplish the mission(s) assigned. Within the scope of the missions which may be assigned, the reserve rifle platoon machinegunners are assigned primary, alternate, and supplementary positions. These gunners fire within their sectors from these positions on order from the platoon leaders.

*b.* Machinegunners in the reserve platoon are assigned the same type sectors of fire as are the gunners in the forward rifle platoons. Final protective lines are *not* assigned to machineguns in the reserve platoon. A principal direction of fire day and principal direction of fire night are assigned these weapons.

*c.* The several alternative and separate missions which may be assigned a reserve platoon complicate the problems of the machinegun crews. Standing operating procedures may create two or more reconnaissance groups to facilitate concurrent reconnaissance of several separate unit positions. Placing of ammunition on several potential positions, where possible, facilitates ammunition supply. Where long foot movement is involved, effort should be made to obtain transportation or additional ammunition carriers from the rifle squads.

*d.* The guns, when possible, are employed on the tripod mount for engagement of targets within the primary sector and fired free gun or from the bipod mount to engage targets within the secondary sector.

*e.* The machineguns of the reserve rifle platoon are normally employed singly because there is a greater area of responsibility, which, with guns employed in pairs, the platoon could not cover.

*f.* The preparation of the weapons squad of the reserve platoon for the defense is otherwise the same as for the weapons squad of the forward rifle platoon.

### 126. Defense of the COPL

The mission of the COPL is to deny the enemy close ground observation of the battle area and provide early warning of his advance. Within its capabilities, it delays and disorganizes the enemy and deceives him as to the true location of the battle area. It avoids close combat when possible. The COPL is organized into outguards for most effective coverage.

*a.* Machinegunners on the COPL are assigned positions, normally with outguards, from which they can cover the greatest portion of the platoon frontage and take full advantage of their long-range fires.

*b.* The gunners on the COPL are assigned primary and secondary sectors of fire. These sectors are assigned in such a manner that they provide a maximum of mutual support for adjacent elements on the COPL. The machineguns are normally employed on tripod to achieve more accurate fires at the maximum effective range of the weapon and to facilitate employing the gun in its predetermined fire role during periods of limited visibility.

*c.* The primary sector should cover areas of tactical significance which allows for engagement of targets out to the maximum effective range of the M60. Final protective lines are not assigned machinegunners on the COPL; therefore, the primary sector limits need not be close to the defensive units. The guns are assigned principal directions of fire day, principal directions of fire night, and will be habitually laid on a principal direction of fire corresponding to the condition of visibility.

*d.* The secondary sectors of fire will cover as much of the frontage as possible and will be engaged using free gun or by removing the gun from its tripod mount and employing the gun on its bipod mount (fig. 120).

The machineguns on the COPL are controlled by the commanders of the outguards to which they are attached.

*f.* Preparation of machinegunners for the defense of the COPL is as detailed as time permits. In addition to normal preparation of positions, reconnaissance of withdrawal routes and possible delay positions is emphasized. In the difficult task of breaking contact without being too closely involved, the machinegunners may well be used to cover the withdrawal of the rest of the force. It is desirable, therefore, that motor transport be available for the gun crews, and that it be kept close behind the gun positions. Where the hostile advance habitually employs mechanized forces, withdrawal must be initiated early and withdrawal routes selected which provide cover and concealment.

### 127. Retrograde Operations

A retrograde operation is any organized movement of a unit to the rear or away from the enemy. It may be forced by the enemy or made voluntarily. Retrograde operations may be classified as a withdrawal, a delaying action, or a retirement. The rifle platoon usually executes retrograde operations as part of the company. Machineguns of the rifle platoon are disposed in all retrograde operations to take maximum advantage of long-range and close defensive fires depending on the condition of visibility.

*a. Withdrawal.* A withdrawal is an operation by which all or a part of a deployed force disengages from the enemy in order to position itself to initiate some other action. The two techniques of executing withdrawals are the *night or deception withdrawal technique* and *daylight or under pressure withdrawal technique.*

(1) The night or deception withdrawal technique is used at night, during other periods of limited visibility, or in the absence of definite enemy pressure. When using night withdrawal techniques, a portion of the force is left on position to simulate normal activities while the remainder of the force withdraws to the rear. Normally one rifle squad and one-half of the crew-served weapons are left. The machinegun(s) left is the one with the best position to deliver close defensive and final protective fires to best protect the defensive position of the element left in contact. In some cases a machinegunner(s) left in contact may be required to move to occupy a position(s) which allows him to obtain close defensive and final protective fires. A machinegun(s) should be assigned a final pro-

tective line, and a principal direction of fire night.

(2) A daylight or under pressure withdrawal technique is used when a unit is forced by enemy action to execute a withdrawal. Units disengage from the enemy by fighting their way to the rear, with units positioned to the rear covering the withdrawal of the forward units. The rifle platoon may use either of three methods of withdrawing: withdrawal by thinning the lines, machineguns withdrawing last; withdrawal by squad maneuver (crew-served weapons attached to squads left in contact); or withdrawal by fire team maneuver, machine guns leapfrogging to the rear. In each situation, machinegunners should occupy positions which permit delivery of long range fire and close defensive fires. Machineguns should be assigned principal directions of fire. Final protective lines are not normally assigned.

*b. Delaying Action.* A delaying action is an operation in which a unit trades space for time and inflicts casualties on the enemy without becoming decisively engaged in combat. The underlying principal of a delaying action is to gain time without fighting a decisive engagement. Machineguns are assigned principal directions of fire. Gunners should occupy positions which permit delivery of fire on the enemy at the maximum effective range of the weapon. Final protective lines are not normally assigned unless the platoon may have to defend a position accepting close combat to accomplish its mission.

## 128 Special Defensive Operations

This paragraph provides the necessary guidance for the *machineguns of the rifle platoon* in conducting special defensive operations.

*a. Reverse Slope Defense* (fig. 124). A reverse slope defense is organized on that portion of a terrain feature which is masked by a crest from enemy direct fire and ground observation. Control of the crest by either fire or physical occupation is necessary. Selection of positions and conduct of the reverse slope defense are the same as in the regular defense. Special considerations are—

(1) Machineguns are located to place grazing enfilade fire on the enemy if possible when he arrives at the crest, and on the forward slope of adjacent terrain features (fig. 124).

(2) Final protective lines and principal directions of fire are employed as in a forward slope defense. Machineguns may occupy temporary forward positions with the observation and security groups initially, and withdraw early.

(3) Machineguns located along the FEBA hold their fire until the enemy crosses the crest. As the enemy advances over the crest of the hill, all available fires are brought on him.

*b. Perimeter Defense.* The organization, preparation, and conduct of a perimeter defense is the same as that discussed in paragraphs 119–123 with one exception—machineguns are *normally* employed singly.

*c. Defense of a Riverline* (fig. 125). Machineguns are positioned to cover dangerous crossing sites and avenues of approach to them. The terrain along a river usually offers excellent fields of fire and permits grazing enfilade fire to be delivered along the front. Final protective lines should be established to give grazing fire *on the river* or the *far bank.*

*d. Relief in Place.* In order to insure the effective delivery of preplanned fires during and immediately after a relief which is conducted during periods of limited visibility, incoming and outgoing crews must exchange tripod mounts. Tripod mounts (complete with traversing and elevating mechanisms), field expedients for delivering preplanned fires, and range cards are left in position by the outgoing crews.

# Section IV. EMPLOYMENT OF THE M60 MACHINEGUNS OF THE RIFLE PLATOON IN THE ATTACK

## 129. General

This section provides guidance for the platoon leader, weapons squad leader, and machinegun crew members in employing the M60 machinegun in the attack. The provisions are applicable to the machineguns of the rifle platoons of the infantry, airborne infantry, and mechanized infantry battalions.

**130. Missions and Fundamentals of Employment**

*a.* The mission of the rifle platoon in the attack is to close with and destroy or capture the enemy. The rifle platoon normally attacks as part of a coordinated company action as described in FM 7-11. It maneuvers under cover of both organic and nonorganic fire support to assault the enemy. The platoon may also be employed as a semi-independent force in which the platoon leader has more freedom of action.

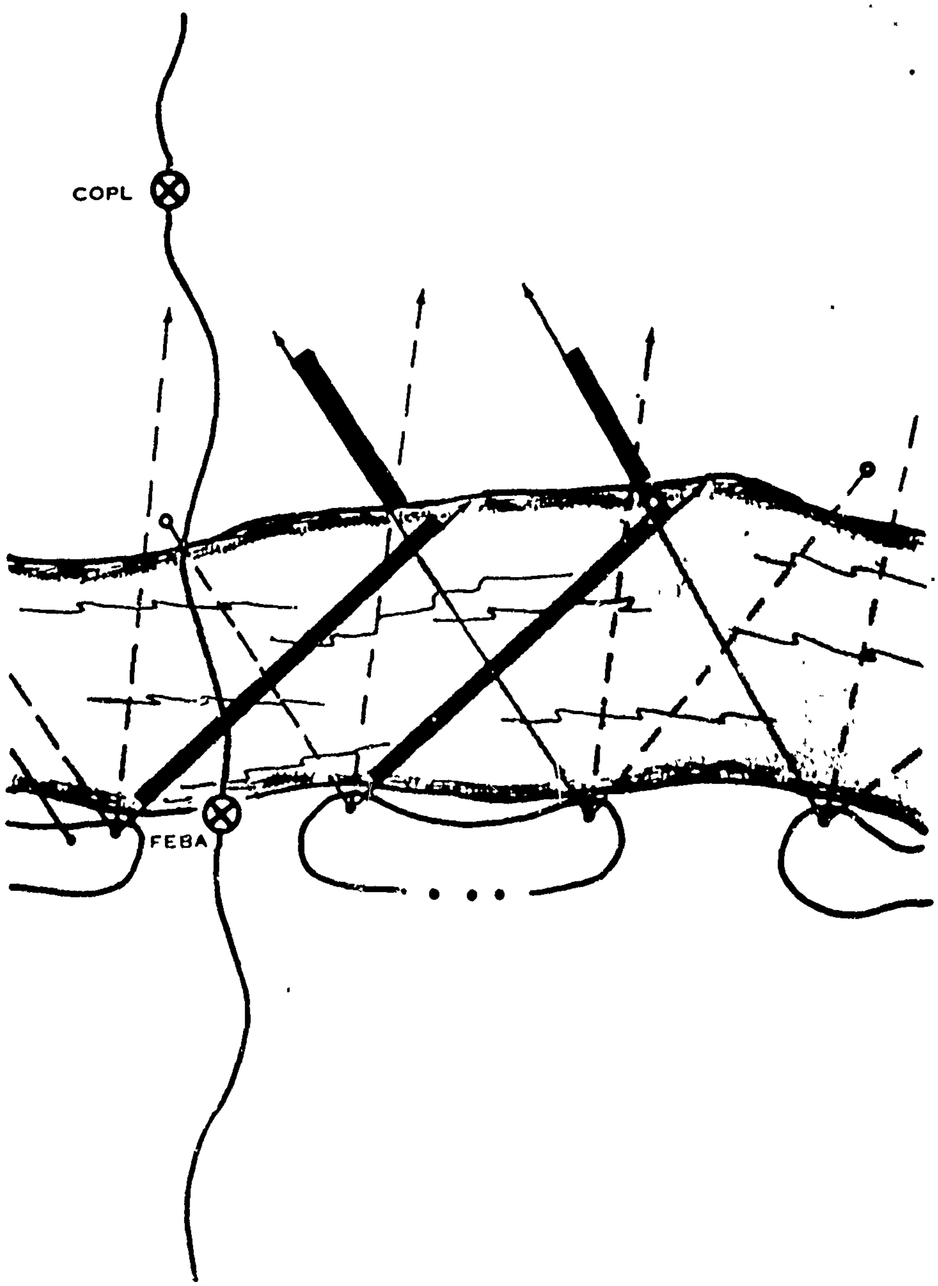



*Figure 125. Defense of a riverline*

maneuvering element, supporting by fire from positions forward of the LD or joining in the assault; or by separating the guns, do both.

*a. Fire Support Element.* Gun crews, which are part of the platoon support element, employ the following procedures to support the attack.

(1) The machineguns set up, under the control of the weapons squad leader, in positions which offer observation, good fields of fire, cover, and concealment.

(2) The squad leader specifies the method and rate of fire to be used in engaging targets. Sufficient fire is placed on targets to neutralize them, but consideration is given to conserving ammunition for other targets which may appear during the attack.

(3) The squad leader anticipates the masking of fire and displaces the weapons by crews. In the absence of a leader, the gunners are responsible for displacement. When the fires of the machineguns are masked by the assaulting element, they are moved forward immediately to join in the assault or to take part in consolidation.

(4) Overhead fire (para. 95–98) may be delivered to aid in supporting the attack. The terrain and visibility dictate when overhead fire can be delivered and the distance overhead fire can be safely delivered by machineguns.

*b. Maneuver Element.* When the gun crews accompany the maneuver element, the following procedures are employed.

(1) Gun crews take positions, with or protecting the formation, which afford best opportunity for prompt delivery of fire should resistance be encountered en route to the objective. When the terrain is rugged and favors such action, the gun(s) may advance by bounds from position to position. Where flat terrain affords no favorable gun position, the crew(s) moves in rear and toward the flank(s) of the rifle elements prepared for prompt action. In such cases, a new potential position should be selected by the gun crew leader as each previously selected potential position is passed. Where overhead fire support is impracticable, position(s) on the flanks of the rifle elements favors fire support by delaying masking of fire by the advance.

(2) During the assault, machinegun fire support may be delivered from well-forward, fixed positions of the type discussed in the preceding paragraph, or the gunners may move the assault element using the techniques of assault fire described in paragraphs 89 through 94.

### 133. Consolidation and Reorganization

*a.* Immediately after seizing the objective, the machinegunners move to preselected positions or to positions which offer good fields of fire to repel a possible counterattack. The machineguns constitute the defensive framework of the platoon and have priority of positions. The machinegunners are assigned defensive missions and begin preparing for the defense as outlined in paragraph 122.

*b.* Reorganization is a continuing process; however, it is given special emphasis upon seizure of the objective. After seizure of the objective, key men who have become casualties are replaced, and ammunition is redistributed.

### 134. Conduct of the Night Attack

*a.* Night attacks are a part of normal operations and become more frequent when firepower makes daylight operations more hazardous. During some periods of limited visibility (fog, smoke, rain, snow, or at night when artificial illumination is used), some or all of the techniques used during period of good visibility may apply. This paragraph deals primarily with a night attack by stealth.

*b.* Night combat is generally characterized by—

(1) A decrease in the ability to place aimed fire on the enemy.

(2) An increase in the importance of close combat, volume of fire, and the fires of certain weapons laid on targets during daylight.

(3) Difficulty of movement.

(4) Difficulty in maintaining control, direction, and contact.

Despite these difficulties, the night attack gives the attacker a psychological advantage in magnifying the defender's doubts, fears, and apprehension of the unknown

c. The conduct of the attack by stealth requires that the attacking elements reach the probable line of deployment without being discovered. If the attack is discovered prior to this, the unit commander may call for illumination and planned supporting fires. If he does call for illumination the attack then continues using the tactics and techniques for a daylight attack.

d. The attacking units move from the assembly area in a column formation. The machinegunners are located in the platoon formation where they can best deploy into the assault formation or separate themselves from the assaulting element if their mission is to support by fire.

e. In the fire support role machineguns support the night attack by fire; they deliver prearranged fires from positions where firing information was obtained during periods of good visibility.

f. Machineguns in the assault.

(1) When the machineguns are a part of the assault element, they move forward in the platoon formation from the probable line of deployment on order. When the attack is discovered, assault fires are initiated. Scattered fire by small elements of enemy must not be taken as loss of surprise and should not be the signal to start the assault fires. The importance of developing a great volume of fire during the assault cannot be overemphasized. It is at this time that fire superiority must be established and maintained. Machinegunners apply techniques of assault fire as described in paragraphs 89 through 94. The assault is conducted aggressively with troops shouting and creating as much noise as possible. The assault continues to the military crest on the far side of the object. Gunners do not move forward of the limit of advance. Solid tracer ammunition is used by the machinegunners to increase accuracy of fire observation and to demoralize the enemy.

(2) When the objective has been seized, the plans for reorganization and consolidation are carried out as described in paragraph 133.

**135. Special Offensive Operations**

This paragraph provides the necessary guidance for the employment of machineguns of the rifle platoon in conducting special offensive operations.

a. *Attack of a Built-Up Area.*

(1) A built-up area is any grouping of buildings such as villages, towns, cities, or factories. After seizing terrain features which dominate approaches to a built-up area, the platoon's next task is to seize enough buildings for a lodgement on the edge of the town. This lodgement reduces or eliminates the defender's ground observation and ability to place direct fire on the approaches to the built-up area.

(2) The machineguns of the rifle platoon are employed initially to provide covering fire for the rifle squad during its attack to seize a platoon foothold in the area. Once a foothold is secured, the machineguns are quickly moved into the built-up area and kept well forward in the platoon where they can provide supporting fire for the platoon's attack. Machinegunners are prepared to deliver grazing fire down streets, alleys, and other open areas. These fires destroy any enemy driven into the open and prevent them from using streets, alleys, and open areas as routes for supply, reinforcement, or maneuver. After seizure of the built-up area, consolidation and reorganization are effected as discussed in paragraph 133.

b. *Attack of a Fortified Area.* The machineguns of the rifle platoon are employed as a part of the fire support element or as a part of the maneuver element.

(1) *Fire support element.* As a part of the fire support element of the platoon, a machinegun(s) neutralizes the fires of the bunker under attack, enemy forces in open emplacements around the bunker, and locations suspected of containing enemy who can hinder the advance of the maneuver element. As the fires of the machinegun(s) become masked by the maneuver element, the machinegunner(s) shifts his fires and

continues to place fire on known and suspected enemy locations.

(2) *Maneuver element.* As a part of the maneuver element, a machinegunner(s) assists in the assault in neutralizing the enemy position by firepower.

c. *River Crossing Operations.* A river crossing operation is used to rapidly move an attacking force across a river obstacle so it may continue the attack to seize the assigned objective(s). There are two types of river crossings: hasty and deliberate. The type of crossing made will depend on factors such as strength of the defenses, size of the river and its current, and the available crossing means. During the conduct of either type river crossing, machineguns of the platoon should make the crossing in separate vehicles.

(1) *Hasty crossing.* A hasty crossing is conducted without extensive preparation and is executed to take advantage of discovered enemy weaknesses in order to maintain momentum and achieve surprise. A single rifle platoon may execute a hasty crossing. During the crossing one or both of the weapons squad machinegunners may be left on the near bank to provide covering fire for the rifle squads. If covering fires from other sources is sufficient, both guns may cross with the rifle squads.

(2) *Deliberate crossing.* A deliberate crossing requires detailed planning and preparation at all levels of command. It may be conducted to resume the offensive, as a result of an unsuccessful hasty crossing, or when a hasty crossing is undesirable because of the difficulty of the obstacle or the strength of enemy defenses. During a deliberate crossing, covering fires are normally provided by weapons other than those organic to the rifle platoon. The platoon normally crosses in squads as a part of a higher unit. Machine guns of the rifle platoon make the crossing with rifle squads to which they are attached. The guns remain assigned to these squads until the platoon consolidates and reorganizes on the objective.

APPENDIX 5 TO ANNEX A

ASSAULT, OVERHEAD, AND POSITION DEFILADE FIRES

(Extracts from FM 23-67)

## Section VI. ASSAULT FIRE

### 89. General

*a.* Machineguns need not always be limited to supporting fire roles in the attack. In many situations the leader can obtain maximum effect from the machineguns by placing them on line in the assault. The procedures described in this section are used when assaulting in a line such as during a night attack or during the final stages of a day assault when fire superiority has been gained.

*b.* To assault successfully, crew members must learn to—

(1) Deliver fire effectively without alining the sights.

(2) Move rapidly and maintain alinement in order to arrive on the objective in the shortest possible time

(3) Reload rapidly to prevent lulls in the firing.

(4) Keep the fire down in the objective area.

(5) Distribute fire properly.

### 90. Firing Positions

There are three firing positions which may be used when firing the gun in the assault. Use of each of the positions at the proper time will enable gunners to place accurate fire on the enemy without alining the sights. With all assault firing positions the gunner adjusts his fire by observing the tracers and the impact of the projectiles in the target area. To provide support for the gun in the assault, a sling is attached to the weapon and placed over the gunner's shoulder. It is primarily used to support the weapon when carried or fired in the underarm and hip positions.

*a. Hip Position* (fig. 98). The hip firing position is used when a heavy volume of fire is desired in the target area and rapid movement is not essential. The hip firing position provides good stability but is awkward to use while moving. Not less than nine rounds are fired in each burst. When firing from this position—

(1) The bipod legs are down for instant use if needed.
(2) The rear sight is down.
(3) The left hand grasps the handguard of the forearm assembly.
(4) The right hand is on the pistol grip.
(5) The rear of the stock is held firmly against the forward portion of the right thigh.
(6) The left foot is pointed in the direction of the target during firing.
(7) The right foot is positioned to the rear to provide stability.
(8) The gunner leans toward the target before and during firing.

*b. Shoulder Position* (fig. 99). The shoulder firing position is used when the gunner desires to hit specific points in the target area and rapid movement is not essential. He pauses momentarily and fires a burst after every two or three steps as the left foot strikes the ground (right handed firer). A maximum of six rounds is fired in each burst. This positi n provides the greatest accuracy. When firing from this position--

(1) The rear sight and bipod legs are down. To aim, the gunner places the top of the front sight blade at the center base of the target.
(2) The gunner's hands and feet are placed the same as when firing from the hip position.
(3) The stock of the weapon is held firmly into the shoulder, and the gunner leans toward the target before and during firing.

*c. Underarm Position* (fig. 100). The underarm firing position is used when closing with the enemy and a heavy volume of fire and rapid movement are required During periods of limited visibility this position is used during the entire assault The gunner's movement is continuous and he fires a *short* burst each time his left foot strikes the ground. A maximum of six rounds is fired in each burst. When firing from this position—

(1) The rear sight and bipod legs are down.
(2) The gunner's hands and feet are placed the same as when firing from the hip position.
(3) The weapon is held firmly between the right arm and the right side of the chest. The gunner leans forward while firing.

## 91. Speed of Movement and Maintaining Alinement

The gun crews must move rapidly and maintain alinement with the other members of the assaulting element in order to reach the objective in mass. To accomplish this the following techniques are used.

*a.* The gunners move as rapidly as possible, consistent with their ability to fire accurately and maintain alinement.

*b.* The gun crew(s) maintains alinement by guiding on the designated base man, maintaining visual contact, and sensing the muzzle flashes and blasts to the flanks.

*c.* The gun crew(s) must not stop during the assault. Stopping disrupts alinement and slows movement.

## 92. Reloading

Gunners and assistant gunners must learn to reload rapidly to avoid lulls in the firing. This can be achieved by practice and by applying the following techniques.

*a. Prior to the Assault.*

(1) The gunner inspects the extended bandoleer supporter for damage.
(2) Assistant gunners remove the cardboard covers from the tops of the bandoleers, check the ammunition to insure it is clean and serviceable, and check the bandoleer loop for serviceability.

*b. During the Assault.*

(1) Gunners use their assistant gunners to assist in reloading the weapon; however, if the assistant gunner is hit, the gunner must continue moving forward and reload as rapidly as possible. The sling will allow the gunner to use both hands to reload

(2) The assistant gunner moves to the left of the gunner carrying a belt of 100 rounds of ammunition, which is attached to the end of the belt in the weapon before it is expended. If the gunner becomes a casualty, the assistant gunner must secure the gun and continue in the assault or move to the objective for the consolidation and reorganization.

### 93. Keeping the Fire Down

*a.* Gunners have a tendency to fire high in the assault. To overcome this they must be trained to make a bold depression of the muzzle when firing, and then adjust upward. It is easier to adjust upward than downward, and by firing low, maximum effect is obtained from ricochets.

*b.* The use of tracer ammunition provides a means of adjusting fire. At night, solid tracer ammunition should be used. In addition to providing a means of adjusting fire, it aids in illuminating the objective area and has a demoralizing effect on the enemy.

### 94. Distributing Fire

To insure that fire is properly distributed over the objective area, gunners fire and adjust rapidly and continuously on as much of the objective area as possible without endangering friendly troops, giving priority to enemy automatic weapons.

## Section VII. OVERHEAD FIRE

### 95. General

*a.* Overhead fire is delivered over the heads of friendly troops. During training it is used *only* when troop safety has been proven. The terrain and visibility *dictate* when overhead fire can be delivered safely.

*b.* Overhead fire *cannot* be safely delivered on a target at a range greater than 850 meters from the gun, and it is not delivered over level or uniformly sloping terrain.

### 96. Delivery of Overhead Fire

*a.* Overhead fire is delivered with guns on *tripod* because of the greater degree of stability and accuracy and the limited capability of measuring vertical mil angles by using the elevating mechanism.

*b.* Ideally, overhead fire is delivered when a depression in the terrain exists between the gun position and the target. The depression should be such that the gunner's line of aim is well above the heads of friendly troops (fig. 101).

*c.* Control is normally accomplished by the weapons squad leader. He lifts or shifts the fire when the feet of the troops in the element being supported reach an imaginary line drawn parallel to the target where further fire would cause casualties to friendly troops. This imaginary line

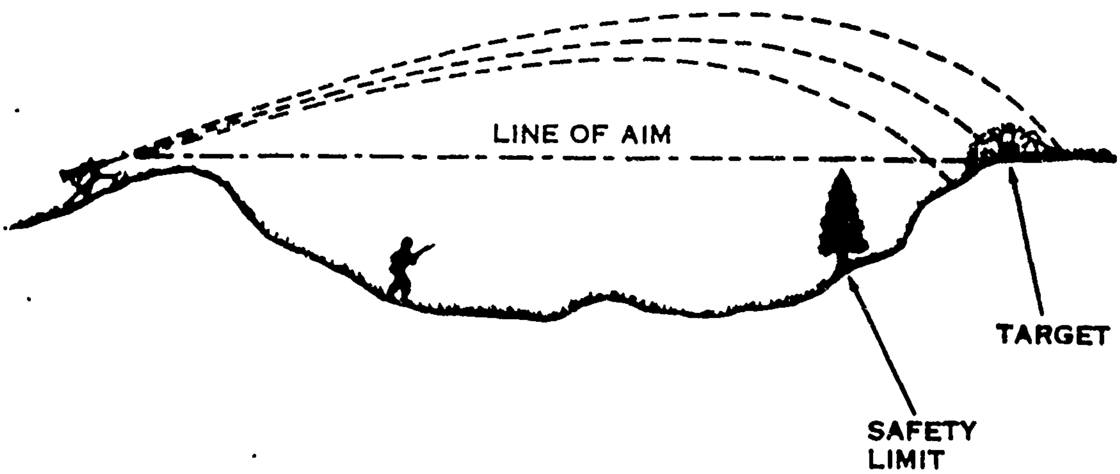



*Figure 101  Delivering overhead fire*

is called the *safety limit* (fig. 101). In some instances the leader of the element being supported will direct lifting of fire at the proper time by prearranged signals which can be transmitted by radio, wire, or visual means.

### 97. Determining the Safety Limit

The *safety limit* can be determined by observation of the fire or by using the gunner's rule (*b* below).

*a.* To determine the *safety limit* by observation the leader uses binoculars to observe the fire with relation to advancing friendly troops.

*b.* A *safety limit* can be selected prior to firing the gun by using the gunner's rule. The accuracy and safety of this method depends on the weapon being *accurately* zeroed (para. 161) and the range to the target being *correctly* determined (para. 70). The gunner's rule is used only when the target is between 350 and 850 meters from the gun. To use the gunner's rule—

(1) Determine the range to the target and set the range on the rear sight.

(2) Lay the gun to hit the target.

(3) Raise the rear sight slide to 1,100 meters.

(4) Depress the muzzle of the weapon 10 mils by using the elevating handwheel (one click equals one mil).

(5) Look through the rear sight and note the point where the new line of aim strikes the ground. An imaginary line drawn through this point and parallel to the target is the *safety limit*.

(6) Reset the range to the target on the rear sight, relay on the target, and prepare to fire.

### 98. Precautions for Overhead Fire

The following safety measures *must* be considered in delivering overhead fire.

*a.* Firmly emplace the tripod mount.

*b.* Use depression stops to prevent the muzzle of the gun from accidentally being lowered below the *safety limit*.

*c.* Do not deliver overhead fire through trees.

*d.* Inform commanders of friendly troops when fire is to be delivered over their heads.

*e.* Insure that all members of the gun crew are aware of the *safety limit*.

*f.* Do not deliver overhead fire if the range from the gun to the target is less than 350 meters or exceeds 850 meters.

*g.* Do not use a barrel which has excessive muzzle blast or is otherwise determined to be badly worn.

*h.* During training exercises—

(1) Do not lay machineguns so their fire will cross at any point over the heads of friendly troops.

(2) Consult AR 385-63 and local safety regulations concerning overhead fire.

## Section VIII. POSITION DEFILADE

### 99. General

In order to achieve *maximum effectiveness*, the machinegun(s) must be employed using the technique of direct lay, however, at times it may be desirable to employ guns from position defilade. A machinegun is in position defilade when the gun and its crew are hidden from enemy ground observation by a land mass such as the crest of a hill. The position may be on the reverse side of the mask or the forward slope of the next high ground in the rear of the mask or in a small fold in the ground (fig 102) The machinegun on bipod mount is not fired from position defilade due to the difficulties encountered in adjusting fire when the gunner cannot see the target

*a. Advantages.*

(1) The gun crew(s) has cover and concealment from aimed small arms fire.

(2) The crew has some freedom of movement in the vicinity of the gun position.

(3) Control and supply are facilitated.

(4) The characteristic smoke and flash of the gun is less easily observed by the enemy.

*b Disadvantages.*

(1) Rapidly moving ground targets are not easily engaged because adjustment of fire must be made through an observer.

(2) Targets close to the mask usually cannot be engaged.

(3) It is difficult to obtain a final protective line

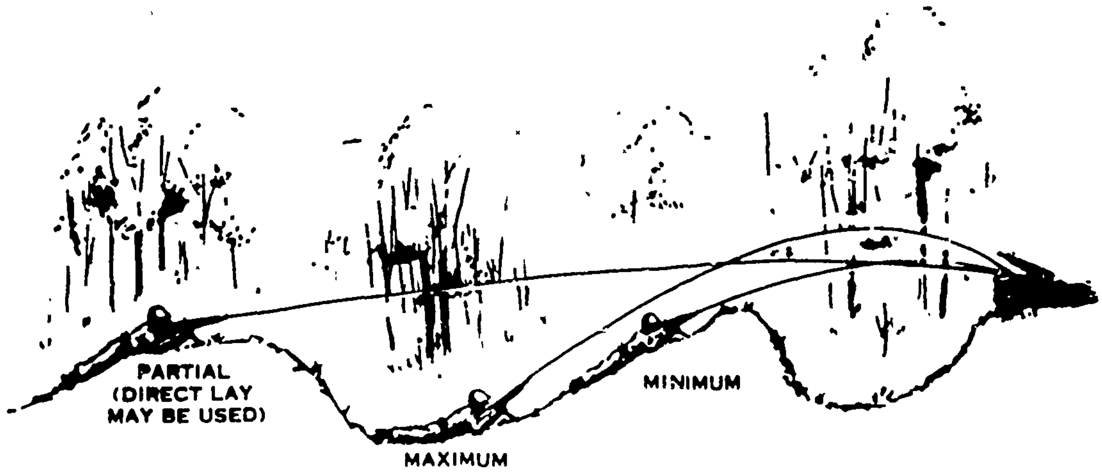



*Figure 102. Types of position defilade.*

## 100. Types of Position Defilade

*a. Maximum Position Defilade.* A gun is in maximum position defilade when it is at the lowest point on a slope from which it can engage the target (fig. 102). It has relatively good cover but lacks flexibility in engaging new targets.

*b. Minimum Position Defilade.* A gun is in minimum position defilade when it is at the highest point on a slope at which position defilade can be obtained (fig. 102).

*c. Partial Defilade.* A gun is in partial defilade when a mask provides the gun and crew with some protection from enemy direct fire, and the gunner is still able to engage the target by direct laying techniques (fig. 102).

## 101. Target Engagement

The essential elements in the engagement of a target from position defilade are mask clearance, direction, elevation, and adjustment of fire. If possible, a minimum mask clearance (minimum elevation) will be determined for the entire sector of fire. However, it may be necessary (due to the slope of the mask) to establish clearance for each individual target.

*a. Establishing Mask Clearance.*

(1) If the mask is 300 meters or less from the gun position, place a 300-meter range setting on the rear sight, lay on the top of the mask, and add three mils (clicks) of elevation with the elevating handwheel

(2) If the mask is over 300 meters from the gun position, place the range setting to the mask on the rear sight, lay on top of the mask, and add three mils (clicks) of elevation.

(3) The elevation reading(s) obtained using the methods outlined in (1) and (2) above, give the minimum elevation for the sector or target(s). The minimum elevation should be recorded.

*b. Laying the Gun for Direction.* The observer places himself to the rear of the gun on the gun-to-target line and in a position where he can see the gun and the target (fig. 103). He alines the gun for general direction by directing the gunner to shift the mount and/or gun until it is alined on the target. A prominent terrain feature or landmark visible to the gunner through his sights is selected as an aiming point This aiming point should be at a greater range than the target and at a higher elevation. When laying the gun on the aiming point, the range setting on the rear sight must correspond to the range to the target.

(1) If the aiming point is on the gun to target line, the gun is laid on the aiming point and is thereby alined for direction.

(2) If the aiming point is not on the gun to target line, the horizontal distance in mils is determined using the best means available (binoculars) and announced to the gunner. This measured

## ANNEX B

## COMBAT ACTIONS INITIALLY CONSIDERED

1. Combat Outpost
2. Delaying Action
3. Roadblocks
4. Retrograde Operations
5. Collapsing Defense in Withdrawal from LZ
6. Deliberate Defense
7. Hasty Defense
8. Counterattack
9. Area or Position Security
10. Fire and Movement
11. Fire and Maneuver
12. Frontal Attack
13. Close Combat
14. Consolidation
15. Exploitation
16. Breaching Operations
17. River Crossing
18. Aerial Assault
19. Ambush
20. Advance to Contact
21. Security of Moving Column
22. Combat in Cities
23. Search and Clear
24. Recon Patrol
25. Counterambush
26. Combat Patrol

## ANNEX C

## CRITICAL COMBAT TASKS

## MACHINE GUN

Medium to short range sustained fire (100 RPM)

Medium to short range rapid fire (200 RPM)

Long range fires increasing in volume

Continuous volume of supporting fire (attack)

Heavy volume of final protective fires (defense)

Accurate predetermined fires based on range card

Medium to short range fire/rapid displacement

Maximum aimed fire-minimum exposure to enemy fire

Alert movement/rapid reaction

Immediate initiation or return of fire

Aggressive deployment and attack

Deliberate methodical movement with detailed observation

Anticipated short and/or medium range enemy contact

Clear fields of fire

Prepare and camouflage positions/emplacements

Put in barriers

Conduct a planned organized withdrawal

ANNEX D

TASK/ACTION CONCEPT TABLE

CRITICAL COMBAT TASKS

MACHINE GUN

| COMBAT ACTIONS | Combat Outpost | Delaying Action | Roadblocks | Retrograde Operations | Collapsing Def Withdrawal LG | Area Pen/Security | Hasty Defense | Deliberate Defense | Counterattack | Frontal Assault | Fire & Movement | Fire & Maneuver | Consolidation | Exploitation | Breaching Operations | River Crossing | Aerial Assault | Ambush | Close Combat | Advance to Contact | Booty Moving Column | Search & Clear | Recon Patrol | Combat Patrol | Counterambush | Combat in Cities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Medium to short range sustained fire (100 RPM) | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | 2 4 | 1 2 4 | 1 2 3 4 | 2 3 4 | 2 3 4 | 1 2 3 4 | 2 4 | 2 3 4 | 2 3 4 | 1 2 3 4 | 2 3 | | 3 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 | 2 3 4 | 1 2 3 4 |
| Medium to short range rapid fire (200 RPM) | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 3 4 | 2 4 | 1 2 4 | 1 2 3 4 | 2 3 4 | 2 3 4 | 1 2 3 4 | | 2 3 4 | 1 2 3 4 | 1 2 3 4 | 2 3 | 2 3 | 3 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 | 2 3 4 | 1 2 3 4 |
| Long range fires increasing in volume | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | | | 2 4 | 1 2 4 | | | | | 2 4 | | | 1 4 | | | | | | | | | | |
| Continuous volume of supporting fire (attack) | | | | | | | | | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 | | | 1 2 3 4 | 1 4 | | | | | | | | | | 1 2 3 4 |
| Heavy volume of final protective fires (defense) | | | | | | | 1 4 | 1 4 | | | | | | | | | | | | | | | | | | |
| Accurate predetermined fires based on range card | | | | | | | 1 4 | 1 4 | | | | | | | | | | | | | | | | | | |
| Medium to short range fire/rapid displacement | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 3 4 | | 1 2 4 | | | | | | | | | | | 2 3 | | | | | | 2 3 | | 1 2 3 4 |
| Maximum aimed fire--minimum exposure to enemy fire | | | | | | | | | | 1 2 4 | 1 2 4 | 1 2 4 | | | | | | | | | | | | | | |
| Alert movement/rapid reaction | | | | | | | | | | | | | | | | | | | | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | |
| Immediate initiation or return of fire | | | | | | | | | | | | | | | | | 2 3 | 2 3 | 2 3 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 4 | 2 3 4 | 2 3 4 |
| Aggressive deployment and attack | | | | | | | | | | | | | | | | | | | 2 3 | 2 3 4 | 2 3 4 | | | | 2 3 4 | 2 3 4 |
| Deliberate methodical movement with detailed observation | | | | | | | | | | | | | | | | | | | | 2 3 4 | | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | |
| Anticipated short and/or medium range enemy contact | | | | | | | | | | | | | | | | 2 3 4 | 2 3 | | | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 | 2 3 4 |
| Clear fields of fire | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | | | 1 2 4 | 1 2 4 | | | | | 1 2 4 | | | | | 2 3 | | | | | | | | 1 2 3 4 |
| Prepare and camouflage positions | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | | | 1 2 4 | 1 2 4 | | | | | 1 2 4 | | | | | | | | | | | | | |
| Put in barriers | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 | | | 1 2 3 4 | 1 2 3 4 | | | | | | | | | | | | | | | | | | |
| Conduct a planned organized withdrawal | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | 1 2 4 | | | | | | | | | | | | | 2 3 | | | | | | | | |

1. Tripod mounted - 2. Biped Mounted 3. Hip or shoulder fired 4. Vehicle mounted

## ANNEX E

## REDUCTION OF COMBAT ACTIONS

1. GENERAL. A task/action concept table was prepared which presented for comparison and analysis the 26 combat actions and the 17 critical combat tasks. Detailed study of this table in which primary emphasis was placed on the actions of the individual crew/weapon combination revealed that certain critical combat tasks are common to one or more combat actions. This similarity allowed the reduction of the combat actions from 26 to 6 representative combat actions, one of which (Fire and Maneuver) was subdivided into two combat actions -- Fire and Maneuver and Fire and Maneuver. The way in which this reduction was accomplished is portrayed graphically in Figure E.1. The rationale behind this reduction is listed below.

2. SELECTED REPRESENTATIVE COMBAT ACTIONS.

a. Retrograde Operations. Comparison of the five combat actions (1) Combat Outposts, (2) Delaying actions, (3) Roadblocks, (4) Retrograde Operations, and (5) Collapsing Defense in W/D from an LZ revealed that all of these combat actions are characterized by long range fires increasing in volume and rapid withdrawal without decisive engagement. Therefore, all of these combat actions were combined into one representative action entitled Retrograde Operations.

b. Deliberate Defense. The combat action (7) Deliberate Defense, is in a class by itself, as the machine guns of the rifle platoon possess combat characteristics which are of major importance in the defense. These are outlined in paragraph 119-122 of FM 23-67 (Appendix 4 to Annex A). Analysis of the referenced paragraphs revealed that the Deliberate Defense is indeed a representative combat action.

c. Ambush. The ambush is a combination of the techniques used in (7) Deliberate Defense followed immediately by the rapid withdrawal called for in (4) Retrograde Operations.

d. Hasty Defense Comparison of the three combat actions, (8) Consolidation, (10) Area or Postion Security, and (9) Hasty Defense, revealed that the three are characterized by minimum preparation time under threat of imminent attack, long range, close defensive and grazing fire. Therefore, the three were combined into one representative combat action entitled Hasty Defense

e. Fire and Maneuver.

(1) Comparison of the seven combat actions, (11) Counterattack, (12) Fire and Movement, (13) Fire and Maneuver, (14) Frontal Assault, (15 Close

Combat, (16) Exploitation, (17) Breaching Operations, and one-half of (18) Counterambush revealed that the actions of the individual/crew weapon combination are very similar. These actions are outlined in paragraphs 129-131, FM 23-67 (Appendix 4 to Annex A). Detailed analysis of the referenced paragraphs permits the formation of a representative combat action entitled Fire and Maneuver.

(2) Further analysis of the representative combat actions and study of paragraph 132, FM 23-67 (Appendix 4 to Annex A), which covers the conduct of the attack, showed that in order to perform Fire and Maneuver there are two required elements. These are the fire support element (Fire and Maneuver) and the maneuver element (Fire and Maneuver). Both elements must perform certain individual/crew tasks which are equally essential to the success or failure of the attack mission. Therefore, the representative combat action Fire and Maneuver was further subdivided into two representative combat actions on which combat flow charts will be prepared.

f. Advance to Contact. Consideration of the individual/crew combination's actions while engaged in the (19) Advance to Contact, (20) Security of a Moving Column, (21) Search and Clear, (22) Combat Patrol, (23) Recon Patrol, and one-half of (18) Counterambush, revealed that these six combat actions are very similar. The common tasks required in each are alert movement with rapid reaction to enemy fire, medium to short-range enemy contact, and 5 of 6 cases of aggressive action to gain and maintain enemy contact. Therefore, 5 of these combat actions and one-half of the sixth action were combined into one representative combat action entitled Advance to Contact.

g. Combat in Cities. The individual/crew tasks required in (24) Combat in Cities, are duplicated in several other combat actions but not in sufficient number in any one of the preceding representative combat actions to be included in one of them. Therefore, Combat in Cities was declared a representative action by itself as was the (7) Deliberate Defense.

h. Special Considerations of Combat Actions. Two combat actions (25) River Crossing, and (26) Aerial Assault, were so complex that the individual/crew actions appear in 3 of the representative actions, (13) Fire and Maneuver, (9) Hasty Defense, and (19) Advance to Contact. However, this occurs only after a form of mobility has been utilized. For these reasons both combat actions were eliminated from detailed consideration.

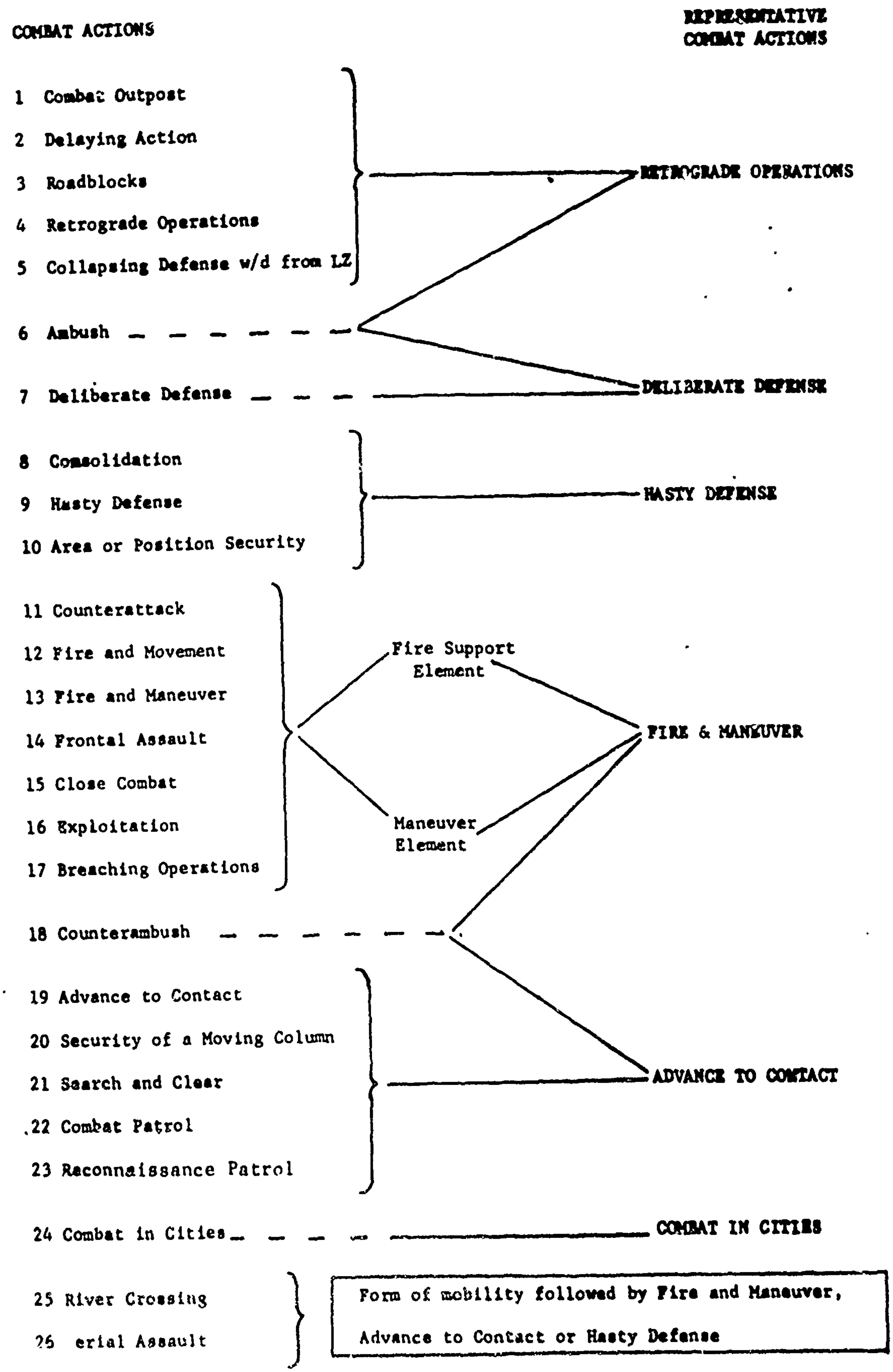

COMBAT ACTIONS
REPRESENTATIVE COMBAT ACTIONS
1 Combat Outpost
2 Delaying Action
3 Roadblocks
4 Retrograde Operations
5 Collapsing Defense w/d from LZ
RETROGRADE OPERATIONS
6 Ambush
7 Deliberate Defense
DELIBERATE DEFENSE
8 Consolidation
9 Hasty Defense
10 Area or Position Security
HASTY DEFENSE
11 Counterattack
12 Fire and Movement
13 Fire and Maneuver
14 Frontal Assault
15 Close Combat
16 Exploitation
17 Breaching Operations
Fire Support Element
Maneuver Element
FIRE & MANEUVER
18 Counterambush
19 Advance to Contact
20 Security of a Moving Column
21 Search and Clear
22 Combat Patrol
23 Reconnaissance Patrol
ADVANCE TO CONTACT
24 Combat in Cities
COMBAT IN CITIES
25 River Crossing
26 erial Assault
Form of mobility followed by Fire and Maneuver, Advance to Contact or Hasty Defense

Figure E-1

## ANNEX F

## DISCUSSION OF MEASURES OF EFFECTIVENESS

1. GENERAL. Consideration of the categories of effectiveness, such as accuracy, responsiveness, reliability, sustainability, etc., revealed that these categories must be defined in terms of measurable parameters which meaningfully relate to a combat situation. Once defined, these parameters were further studied and developed into measures of effectiveness (MOE) in order to measure small differences between competing weapons systems and thereby evaluate them properly and effectively. These MOE evolved in four way:

a. Measures that must be collected in order to compile other data, for example, number of hits. By itself this measurement has little meaning, but when combined with number of rounds fired, a hit probability can be derived.

b. Measures that stand alone, for example, time to first round. This measure of effectiveness stands alone as a measure of the amount of time it takes to fire a round once a target is identified.

c. Measures that are combinations of two or more measures, for example, number of hits per burst is a consideration of:

$$\frac{\text{Number of target hits}}{\text{Number of bursts fired}} = \text{Number of hits per burst}$$

d. Measures specifically designed to evaluate special situations, for example, time to change barrels is an MOE designed for evaluating machine guns. The MOE are shown in the review by category of effectiveness.

2. ACCURACY. The six measures considered in the category of accuracy are:

a. Number of hits. This information is best collected in real time by electronic methods and is used to compile other data, e.g., when combined with the number of rounds fired, various types of hit probability may be derived.

b. Distribution of near misses. This data must be collected with some type of sophisticated instrumentation and is used for a pattern of fire analysis. With this analysis the cone of fire and the subsequent beaten zone can be determined.

c. Hit probability per trigger pull. This is a combination measurement which is required in comparing two weapons and to determine the basic accuracy of a particular weapon. Since the hit data are collected electronically it can be determined which rounds (number 1, 2, 3, 4) of a 6-to-9-round burst pass through the target.

$$\frac{\text{Number of target hits}}{\text{Number of targets engaged}} = \text{Hit probablilities per trigger pull}$$

d. Hit probability - sustained rate of fire.

"The sustained rate of fire is 100 rounds per minute in bursts of six to nine rounds at 4- to 5-second intervals (a barrel change is recommended after firing the sustained rate for 10 minutes)." FM 23-67, paragraph 81b.

Hit probability for the machine gun cannot be simply defined as the number of target hits over the number of rounds fired equals hit probability. Inasmuch as the machine gun has certain characteristics of fire, classes of fire with respect to the ground, target and gun, and two prescribed rates of fire, a total hit probability of the individual/crew weapon combination can be derived by comparing the following data:

(1) $\frac{\text{Number of target hits}}{\text{Number of rounds fired}}$ = per cent of hits

(2) $\frac{\text{Number of targets hit}}{\text{Number of targets exposed}}$ = per cent of targets hit

(3) $\frac{\text{Number of arrays hit}}{\text{Number of arrays exposed}}$ = per cent of arrays hit

(4) $\frac{\text{Number of target hits}}{\text{Number of bursts}}$ = number of hits per burst

(5) $\frac{\text{Number of targets hit}}{\text{Number of bursts}}$ = number of targets hit per burst

An analysis of this type will enable the test officer to study in detail the many facets of the candidate machine gun's hit probability in the sustained rate of fire.

e. Hit probability - rapid rate of fire.

"The rapid rate of fire is 200 rounds per minute in bursts of six to nine rounds at 2- to 3-second intervals. (A barrel change is recommended after firing the rapid rate for two minutes.)" FM 23-67, paragraph 81b.

Hit probability for the machine gun cannot be simply defined as the number of target hits divided by the number of rounds fired. Since the machine gun has certain characteristics of fire, two prescribed rates of fire, and classes of fire with respect to the ground, the target and the gun; a total hit probability of the individual/crew weapon combination can be derived by collecting and comparing the following data:

(1) $\frac{\text{Number target hits}}{\text{Number rounds fired}}$ = per cent of hits

(2) $\frac{\text{Number targets hit}}{\text{Number targets exposed}}$ = per cent of targets hit

(3) $\frac{\text{Number of arrays hit}}{\text{Number of arrays exposed}}$ = per cent of arrays hit

(4) $\frac{\text{Number of target hits}}{\text{Number of bursts}}$ = number of hits per burst

(5) $\frac{\text{Number of targets hit}}{\text{Number of bursts}}$ = number of targets hit per burst

An analysis of this type will enable the test officer to study in detail the many facets of the candidate machine gun's hit probability in the rapid rate of fire.

f. Hit probability in point fire (aperture - enemy machine gun). Point targets are targets which require the use of a single aiming point, enemy bunkers, weapons emplacements, vehicles, and small groups of personnel are all examples of point targets. These types of targets are by their very nature and normal small size more difficult to engage than area targets where several aiming points are used. The data gathered from this type firing will provide valid information on the overall inherent accuracy of the individual/crew weapon combination.

3. RESPONSIVENESS. Since both the light machine gun and the general-purpose machine gun can be operated by a single man under emergency conditions, and since several of the combat actions (and the critical combat tasks required to accomplish them) require the handling of the machine gun by a single man, responsiveness must be measured. All range test facilities measure responsiveness to some degree but the quick-fire range most effectively measures the responsiveness of the individual/crew weapon combination in the shoulder, underarm, or hip firing techniques of fire. The six measures of effectiveness considered in the category of responsiveness are:

a. Time to first round. This MOE provides data on the length of time it takes the firer, from target exposure, to identify the target, assume a firing position, align the sights, align the target with the sights, and fire the first round. The importance of this measure varies from combat action to combat action. As in several of the combat actions, particularly those in which alert movement is required, a quick response to surprise fire is essential.

b. Time to first hit. This MOE provides data on the length of time it takes the firer, from target exposure, to identify the target, assume a firing position, align the sights, align the target with the sights, and fire until a hit is achieved. Ideally, this should be the same amount of time required for "a" above, give or take a few milliseconds for the time of flight of the bullet. The value of this MOE is relatively high since a hit must be achieved for mission accomplishment. Acquistion time is considered relatively constant whether the firer achieves a hit or not; therefore, the MOE time to first round is actually the time required to aim and achieve a hit. In a 2-weapon comparison the weapon requiring the least amount of time and rounds between first round and first hit could be the deciding factor.

c. Time between bursts. This MOE provides information on recoil when firing from any of the assault fire positions, particularly the shoulder-fire position. After firing a burst of 6 to 9 rounds, the firer must reacquire the target, realign the sights and target, then refire. It is only collected in those instances where more than one burst is fired. Additionally, this MOE can be used to ascertain the exact rate of fire by recording the time between bursts when the individual/crew weapon combination engages targets from the tripod or bipod mount using either the sustained or rapid rate of fire.

d. Time to shift fire. This MOE is a combination measurement that provides data on the time required to shift fire to another target after achieving a target hit, and it incorporates the acquirement of a new target, position change time (if required), sight manipulation time (if required), sight alignment, and firing. Sight configuration on present machine gun systems required the firer to raise his line of sight from the weapon, to perceive other targets, then to realign the weapon with the new target while sighting and firing the weapon. This measurement can be taken from all four configurations of mounts: (1) tripod, (2) bipod, (3) hip or shoulder fire, and (4) vehicle mounted.

e. Sight manipulation time. This MOE provides data on the amount of time required to place the correct sight settings on the rear sight leaf while firing. This may entail such things as turning the elevating knob or the windage knob, raising the rear sight leaf, adjusting the rear sight slide, or lowering the rear sight leaf.

NOTE: This meacurement will only apply while zeroing the gun and during the initial lay of the gun on the target for the first time.

"All machine gunners strive for an accurate initial burst. However, an accurate initial burst may not always be obtained; therefore, gunners must have a means of rapidly and accurately adjusting their fire onto the target without going through the time-consuming process of making sight adjustments. This is known as the adjusted aiming point method of fire adjustment.

"If the gunner misses the target with his initial burst, he must select a new aiming point on the ground the same distance from the target as the center of impact of the initial burst but in the opposite direction, and fire a second burst." FM 23-67, paragraph 162.

f. All of the above measures (a through e) are compiled and can be computed as separate functions of range, target type, firing angle, position of firer, and type of mount. For example:

(1) Range. There will be a difference in time for all of the MOE in that category of responsiveness based on range -- 20 meters, 80 meters, or 400 meters -- as range will directly affect the time required to align the sights and the target.

(2) Target type. The various sizes of targets found on the battlefield (men, vehicles, bunker apertures) and their ability to move at varying speeds (man and vehicles) must be taken into consideration when collecting and computing data on the MOE.

(3) Firing angle. The firing angle may be expressed in degrees and direction such as 90° left or 45° right; in addition, horizontal angle must be considered and is expressed as 5° below or above the horizontal. Both of these angles must be taken into consideration when collecting and computing data on the MOE.

(4) Position of firer. Supported or unsupported firing positions, prone, kneeling or standing, all must be considered when collecting and computing data on the MOE.

(5) Type of mount. In the machine gun the type of mount or the configuration of the gun platform, e.g., bipod, tripod or vehicle mount, must be considered when collecting and computing data on these MOE.

g. The combat critical category of responsiveness provides more information about the compatibility of the individual/crew weapon combination than any other category of measurement. This becomes evident as it is realized that of the 7 categories of effectiveness, 3 are derived from mathematical computations (accuracy, sustainability, and reliability) and 3 are a combination of judgment and time or intensity measures (signature effects, portability and compatibility, and stability). Responsiveness alone stands as a measure that considers the time required to accomplish correctly specified actions in order to fire and achieve a hit.

. SUSTAINABILITY.

a. This category of effectiveness reflects the combat life of a weapon in a combat-type environment with respect to the basic load of ammunition for the weapon. All measures of effectiveness (total rounds, number of rounds per minute, number of rounds to first hit, number of rounds between hits, and number of rounds fired per engagement) are contributive and are collected in other categories of effectiveness by instrumentation. Sustainability, therefore, can best be described as hit per pound (as per cent of basic load).

b. Sustainability relates the combat effectivenss of the individual/crew weapon system to its basic load and attempts to provide the duration of time the individual/crew weapon combination can participate in a combat action. These measures can be expressed as per cent of basic load expended per round fired, per burst, per engagement, per range, per target, or any combination thereof. For example:

(1) Weapon A + basic load of 1000 rounds = 23 + 63 = 86 lbs

Rounds between hits (RBH) = 27

Number of engagements (N) = 20

Number of hits (H) = 20

Total rounds fired = RBH x N + H = 27 x 20 + 20 = 560

Per cent of basic load expended $\frac{TRF}{BL} = \frac{560}{1000} = 56\%$

(2) Weapon B + basic load of 2360 rounds = 15 + 70.80 = 85.8 lbs

Rounds between hits (RBH) = 35

Number of engagements (N) = 20

Number of hits (H) = 20

Total rounds fired = RBH x N + H = 35 x 20 + 20 = 720

Per cent of basic load fired = $\frac{TRF}{BL} = \frac{720}{2360} = 30.5\%$

(3) Weapon C + basic load of 2466 = 12 + 73.80 = 85.8 lbs

Rounds between hits (RBH) = 42

Number of engagements (N) = 20

Number of hits (H) = 20

Total rounds fired = RBH x N + H = 42 x 20 + 20 = 860

Per cent of basic load fired = $\frac{TRF}{BL} = \frac{860}{2466} = 34.87\%$

A comparison of the above data reveals that hypothetical Weapon A has a better hit probability than Weapon B or C but that Weapons B and C are better weapons pound for pound in a sustained engagement.

5. RELIABILITY. The six measurements of effectiveness considered in the category of reliability are:

a. Time to load (reload). This MOE can be collected in two ways: by stopwatch or by electronic means while firing from a static position. Time required will vary depending on the feeding system of the machine gun which could be any of the following:

(1) Detachable box magazines.

(2) Detachable drums.

(3) Cloth belt feeds.

(4) Disintegrating metallic split link belt.

b. Time to clear malfunctions/stoppages.

(1) A malfunction is a failure of the machine gun to function satisfactorily. Defective ammunition or improper operation of the machine gun by a crew member is not considered a malfunction. Two of the more common malfunctions are sluggish operation and runaway gun.

(2) Stoppage is any interruption in the cycle of functioning caused by faulty action of the gun or faulty ammunition.

(3) Stoppages are classified by their relationship to the cycle of functioning; for example, failure to feed, failure to chamber, failure to fire, failure to extract, failure to eject, and failure to cock.

(4) Analysis of this MOE must not only include the time to clear the malfunction stoppage but the type of malfunction/stoppage. Those malfunctions attributable to improper operation of the machine gun by the individual/crew will be of particular interest to the test officer as they may indicate deficiencies in crew training or a lack of simplicity of design.

c. Time between malfunction/stoppages. This MOE must be collected in real time during sustained firing situations which are usually found in defensive situations. The analysis, in addition to determining the mean time between the malfunctions/stoppages, can also determine the mean time between the various types of malfunctions/stoppages. Of necessity, this type of information must be recorded and collated by a data processor.

d. Number of rounds between malfunctions/stoppages. This MOE must be sequentially counted by round fired, from the initial round fired throughout completion of all firing exercises. The data obtained from this MOE are necessary to compute the probability that a burst will be fired when the trigger is pulled.

e. Time to change barrel. This MOE must be collected for a valid comparison of any candidate machine gun that uses a belt loading system. The belt feed loading system causes rapid barrel overheating due to the continuous fire capability such a system affords. To overcome this problem a rapid barrel change feature or more efficient cooling system must be incorporated into the candidate machine gun.

6. PORTABILITY AND COMPATIBILITY.

a. The measurements of effectiveness considered in the category of portability and compatibility vary from combat action to combat action, are difficult to measure accurately, and cannot generally be measured with instrumentation. The entire category is considered to be a human factors judgment area and will be considered in each combat action to detect anything about the weapon which may hinder the man/weapon combination performance. For example, the ease of handling the machine gun during movement might be excellent while the barrel is cold, but once heated by sustained fire the ease of handling of the machine gun during movement may suddenly be extremely poor.

b. Performance measures include but are not limited to the following:

(1) Movement times. This measurement evaluates speed of movement with the weapon in various combat situations.

(2) Preparation of positions. This measurement evaluates speed of position preparation and reaction time of the individual/crew with weapon to enemy activity in those combat actions that require the preparation of a position.

(3) Emplacement of barriers. This measurement evaluates speed of barrier emplacement and reaction time of the man with weapon to enemy activity in those combat actions that require the preparation of a position.

(4) Maneuverability when changing positions. This measurement evaluates the speed and ease in which the man/weapon combination changes positions (either by short rushes or a quick-fire role) in order to compile data for a 2-weapon comparison.

(5) Maneuverability when crossing obstacles. This measurement evaluates the speed and ease in which the man/weapon combination negotiates a given obstacle in order to compile data for a 2-weapon comparison

7. SIGNATURE EFFECTS. The four measurements considered in the category of signature effects are:

a. Sound level recording (blast). This signature effect will be measured and evaluated in two parameters: one to determine if there is any danger to the firer's and to adjacent firers' ears; and, two, to determine if the sound of the weapon will readily identify its location on the battlefield.

b. Light reduction (smoke a d haze). This signature effect will be measured and evaluated in two parameters: to determine if the muzzle blast kicked dirt and dust into the air in sufficient amounts to interfere with the sighting and aiming process; and to determine if this same dirt and dust will disclose the firer's position.

c. Visual light emission (flash). This signature effect will be measured. The muzzle flash is the most noticeable signature effect and as such tends to disclose the firer's position. Flash can be measured in such terms as size, duration, and intensity during day and night conditions.

d. Ejection patterns. This signature effect will be measured in terms of distance, pattern, and trajectory of expended shell casings and disintegrating metal links, if applicable. The data compiled for each combat action will be evaluated to see if the ejection patterns interfere with the gunner or other crew member.

8. STABILITY.

a. The stability of the gun platform is a vital consideration, particularly when firing the sustained or continuous volume of fire required in several of the combat actions. For example, should the right bipod leg collapse during sustained firing, the firing effectiveness of the individual/crew weapon combination would be greatly impaired.

b. The tests of bipod, tripod and vehicle mount stability could be conducted simultaneously with other firing exercises. The mounts will be tested on various types of terrain: muddy, wet, solid, high grass, dry grass, sand bags, logs, etc., as well as in the various combat actions. The mounts will be observed in each varying situation to detect anything about the weapon which may hinder the individual/crew weapon combination.

# ANNEX G*

## COMBAT FLOW CHARTS

1. A realistic evaluation of weapon performance cannot be undertaken with validity in a sterile laboratory situation. As an example, the known distance range can more easily be classified as a laboratory than a tactical weapons effectiveness test and, therefore, has become a less important factor in weapons evaluation.

2. The movement in recent years has been towards tactical or operational testing. The combat situation is rich with influencing factors and interactions of factors. Equipment must function in this environment and is affected to some extent by all influencing factors. Fatigue, noise, dust, smoke, stress, dirt, rain, and morale are among those variables that make their influence felt in combat. For weapon evaluation the environment is even richer, because other factors such as terrain, vegetation, enemy tactics, enemy weapons, temperature, field of fire, and engagement ranges are also outside influences. Obviously, every possible combination of influencing factors cannot be used as a basis for testing weapons. Therefore, the amount of influence exerted by these factors should be determined and, if important, should become part of the test environment.

3. The most important single influence on any test is man himself, and since the Infantry Board is assigned the mission of conducting service tests using the type of soldiers who will be using the test weapons/equipment if adopted, test planning and execution are therefore formulated around the individual/crew weapon combination.

4. The combat flow charts were designed and constructed to show each of the 7 combat actions as being an individual/crew action characterized by specific combat tasks which can be measured and evaluated by the developed MOE. This procedure has been portrayed on the first two sheets of each combat flow chart. The third and fourth sheets of the combat flow charts delineate both the rationale and the detailed rationale for selecting the various MOE in evaluating a specific combat action.

* With 7 appendices.

## LIST OF APPENDICES TO ANNEX G

1. Deliberate Defense, Combat Flow Chart

2. Hasty Defense, Combat Flow Chart

3. Retrograde Operations, Combat Flow Chart

4. Fire and Maneuver, Combat Flow Chart

5. Fire and Maneuver, Combat Flow Chart

6. Advance to Contact, Combat Flow Chart

7. Combat in Cities, Combat Flow Chart

## APPENDIX 1 TO ANNEX G

## DELIBERATE DEFENSE, COMBAT FLOW CHART

| Combat Action | Individual/Crew Actions | Characterized by |
| --- | --- | --- |
| Deliberate Defense | Clear fields of fire, prepare and camouflage position/emplacement. Engage enemy from fixed location. | Medium to short range sustained and rapid fires, heavy volume of final protective fires, from static positions, day and night actions |

"Rifle platoon machine guns possess combat characteristics which are of major importance in the defense. Machine guns can -- (1) Produce a heavy volume of direct fire. (2) Deliver grazing fire out to 600 meters. (3) Produce sustained fire for a prolonged period. (4) Effectivenely engage targets at ranges out to 1100 meters. (5) Deliver accurate predetermined fires based upon direction and elevation data. (6) Deliver overhead fire. To exploit these characteristics, machine guns located along the forward edge of the battle area provide maximum fire support by participating in the delivery of long range fires, close defensive fires, and final protective fires." FM 23-67, para 119.

| CATEGORY | DELIBERATE DEFENSE MEASURES OF EFFECTIVENESS |
| --- | --- |
| ACCURACY | Number of Hits<br>Hit Probability Per Trigger Pull<br>Distribution of Near Misses<br>Hit Probability in Sustain Rate of Fire<br>Hit Probability in Rapid Rate of Fire<br>Hit Probability in Point Fire (Aperture) |
| RESPON-SIVENESS | Time to First Round<br>Time to First Hit<br>Time Between Bursts<br>*Time to Shift Fire<br>Time Between Hits<br>Sight Manipulation Time |
| SUSTAIN-ABILITY | *Hits per Pound as per cent of Basic Load |
| RELI-ABILITY | Time to Load (Reload)<br>Time to Clear Malfunctions/Stoppages<br>Time Between Malfunctions/Stoppages<br>*Number of Rounds Between Malfunctions/Stoppages<br>Time to Change Barrel |
| PORTA-BILITY AND COMPATI-BILITY | Movement Times<br>Crew Drill Times<br>Prepare and Camouflage Positions/Emplacements<br>Compatibility with Other Items of Equipment<br>Ease of Handling During Movement (Hot/Cold)<br>Clear Fields of Fire<br>Conduct Reconnaissance of withdrawal Routes<br>Time Required to Change Position<br>Ease of Maintaining Readiness Posture |
| SIGNATURE EFFECTS | Sound Level Records (Blast)<br>Light Reduction (Smoke and Haze)<br>*Visual Light Emission (Flash)<br>Ejection Patterns |
| STABILITY | Stability of Bipod Legs<br>*Stability of Tripod Mount<br>*Stability of Vehicle Mount |

* Denotes most important MOE

## DELIBERATE DEFENSE RATIONALE

Necessary to compile and compute other data

Best overall measure of accuracy as all data are considered

Necessary for pattern analysis and suppressive fire data

Necessary for 2-weapon comparison of sustained rates of fire

Necessary for 2-weapon comparison of rapid rates of fire

Necessary to determine point fire accuracy for 2-weapon comparison

---

Not important as fire may be deliberately withheld

Not important as fire may be deliberately withheld

Necessary to ascertain exact rate of fire and provides information on recoil and aiming problems

Most important measure as individual/crew is in best possible position to engage enemy

Not as important due to the nature of the defense

An important measure in a 2-weapon comparison

---

Provides most reliable information on potential staying power of candidate weapons

---

Necessary data for 2-weapon comparison; affects rate of fire

Necessary data for 2-weapon comparison during extended engagements

Necessary data for 2-weapon comparison during extended engagements

Most important indicator of weapon reliability in sustained engagements

Must be measured in order to ascertain any problems in firing the rapid cyclic rate

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Not applicable

Necessary data for 2-weapon comparison

Not applicable

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Most likely to give away defensive position

Necessary data for 2-weapon comparison

---

Can be measured but machine gun will normally be tripod-mounted

The stability of the tripod can best be measured in the defense

The stability of the vehicle mount will be best tested for sustained firing during extended engagements

DELIBERATE DEFENSE
DETAILED RATIONALE

| | |
|---|---|
| ACCURACY | Hit probability per trigger pull measures the overall effectiveness of the individual/crew weapon combination for all target engagements regardless of range, position, or cyclic rate of fire. |
| RESPONSIVENESS | Time to shift fire is the best measure of responsiveness for the deliberate defense. The individual/crew weapon combination from a fixed, supported, well-protected position is able to best engage a variety of advancing targets. |
| SUSTAINABILITY | Since the deliberate defense is characterized by medium to short-range sustained and rapid fires and a heavy volume of final protective fires, it is imperative that potential staying power is measured. |
| RELIABILITY | In the deliberate defense, which is characterized by heavy volumes of fire for sustained periods of time, the most important measure of reliability is the number of rounds between malfunctions/stoppages. |
| PORTABILITY AND COMPATIBILITY | Each candidate weapon must be closely evaluated to detect any hindrance caused by the weapon in regard to movement, use, or fit with the individual, the crew or their equipment. |
| SIGNATURE EFFECTS | Visual light emission is the most important position disclosure effect when firing is conducted from well prepared, well camouflaged defensive positions/emplacements both day and night. |
| STABILITY | The stability of the tripod mount can best be tested in the deliberate defense posture which is characterized by heavy volumes of close defensive fires and final protective fires. |

## APPENDIX 2 TO ANNEX G

## HASTY DEFENSE, COMBAT FLOW CHART

| Combat Action | Individual/Crew Actions | Characterized by |
|---|---|---|
| Hasty Defense | Clear fields of fire, begin preparation of position/ emplacement, be prepared for immediate assumption of assigned mission(s). | Minimum preparation time under threat of imminent attack, long range, close defensive and grazing fires. |

"The machine guns constitute the defensive framework of the platoon and have priority of position. The machine gunners are assigned defensive missions and begin preparing for the defense as outlined in paragraph 122." FM 23-67, para 133.

| CATEGORY | HASTY DEFENSE MEASURES OF EFFECTIVENESS |
|---|---|
| ACCURACY | Number of Hits<br>* Hit Probability Per Trigger Pull<br>Distribution of Near Misses<br>Hit Probability in Sustained Rate of Fire<br>Hit Probability in Rapid Rate of Fire<br>Hit Probability in Point Fire (Enemy Automatic Weapon) |
| RESPONSIVENESS | Time to First Round<br>Time to First Hit<br>Time Between Bursts<br>Time to Shift Fire<br>* Time Between Hits<br>Sight Manipulation Time |
| SUSTAINABILITY | * Hits Per Pound as Percent of Basic Load |
| RELIABILITY | Time to Load (Reload)<br>Time to Clear Malfunctions/Stoppages<br>Time Between Malfunctions/Stoppages<br>* Number of Rounds Between Malfunctions/Stoppages<br>Time to Change Barrel |
| PORTABILITY AND COMPATIBILITY | Movement Times<br>Crew Drill Times<br>Prepare and Camouflage Positions/Emplacements<br>Compatibility with Other Items of Equipment<br>Ease of Handling During Movement (Hot/Cold)<br>Clear Fields of Fire<br>Conduct Recon of withdrawal Routes<br>Time Required to Change Position<br>Ease of Maintaining Readiness Posture |
| SIGNATURE EFFECTS | Sound Level Records (Blast)<br>* Light Reduction (Smoke and Haze)<br>Visual Light Emission (Flash)<br>Ejection Patterns |
| STABILITY | Stability of Bipod Legs<br>Stability of Tripod Mount<br>Stability of Vehicle Mount |

* Denotes most important MOE

HASTY DEFENSE RATIONALE

Necessary to compute and compile other data
Best overall measure of accuracy as all data are considered
Necessary for pattern analysis and suppressive fire data
Necessary data for 2-weapon comparison of sustained rate of fire
Necessary data for 2-weapon comparison of rapid rate of fire
Necessary data for 2-weapon comparison of point fire accuracy

---

Necessary to compile and compute other data
Important measure as it denotes mission accomplishment
Necessary to obtain exact rate of fire and to compute other data
Main indicator of weapon responsiveness in the hasty defense
Most important indicator of mission accomplishment in the hasty defense
Necessary data for a 2-weapon comparison

---

Provides most reliable information on protective staying power of candidate weapons in the conduct of the hasty defense

---

Necessary data for 2-weapon comparison, affects rate of fire
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Most important indicator of weapon reliability
Necessary data for 2-weapon comparison

---

Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Not applicable

---

Necessary data for 2-weapon comparison
Most likely to give away defensive position
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison

---

Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison

---

## HASTY DEFENSE
## DETAILED RATIONALE

| | |
|---|---|
| ACCURACY | Hit probability per trigger pull measures the overall effectiveness of the individual/crew weapon combination for all target engagements regardless of range, position, or cyclic rate of fire. |
| RESPONSIVENESS | Because of the precariousness of the hasty defense with its limited position preparation and lack of ammunition reserves the time between hits will dictate mission accomplishment or failure. |
| SUSTAINABILITY | Since ammunition on hand will normally be limited to that carried, the relative staying power of the candidate weapons must be measured. |
| RELIABILITY | In the hasty defense, which is conducted from partially prepared positions, the maintaining of fire superiority is mandatory. Therefore, any malfunction/stoppage would be detrimental to mission success. |
| PORTABILITY AND COMPATIBILITY | Each candidate weapon must be closely evaluated to detect and hindrance caused by the weapon in regard to movement, use or fit with the individual, the crew or their equipment. |
| SIGNATURE EFFECTS | In the hasty defense, which is characterized by partially completed positions the signature effect most likely to give away the position is dust from the weapon's muzzle blast. |
| STABILITY | The stability of all mounts may be tested in the environment presented by the combat action, hasty defense. |

APPENDIX 3 TO ANNEX C

RETROGRADE OPERATIONS, COMBAT FLOW CHART

| Combat Action | Individual/Crew Actions | Characterized By |
|---|---|---|
| Retrograde Operations | Clear fields of fire, prepare and camouflage positions/emplacements, conduct recon of withdrawal routes, engage enemy w/accurate fires at maximum effective ranges, rapid withdrawal. | Long-range and close defensive fires increasing in volume, rapid withdrawal without decisive engagement |

"Machine guns of the rifle platoon are disposed in all retrograde operations to take maximum advantage of long-range and close defensive fires depending on the condition of visibility . . . . Machine guns should be assigned principal directions of fire. Final protective lines are not normally assigned." FM23-67, para 127.

| CATEGORY | RETROGRADE OPERATIONS MEASURES OF EFFECTIVENESS |
| --- | --- |
| ACCURACY | Number of hits |
| | * Hit Probability Per Trigger Pull |
| | Distribution of Near Misses |
| | Hit Probability in Sustained Rate of Fire |
| | Hit Probability in Rapid Rate of Fire |
| | Hit Probability in Point Fire (Aperture) |
| RESPONSIVENESS | Time to First Round |
| | Time to First Hit |
| | Time Between Bursts |
| | * Time to Shift Fire |
| | Time Between Hits |
| | Sight Manipulation Time |
| SUSTAINABILITY | * Hits Per Pound as Percent of Basic Load |
| RELIABILITY | Time to Load (Reload) |
| | Time to Clear Malfunctions/Stoppages |
| | Time Between Malfunctions/Stoppages |
| | * Number of Rounds Between Malfunctions/Stoppages |
| | Time to Change Barrel |
| PORTABILITY AND COMPATIBILITY | Movement Times |
| | Crew Drill Times |
| | Prepare and Camouflage Positions/Emplacements |
| | Compatibility with other Items of Equipment |
| | Ease of Handling During Movement (Hot/Cold) |
| | Clear Fields of Fire |
| | Conduct Recon of withdrawal Routes |
| | Time Required to Change Position |
| | Ease of Maintaining Readiness Posture |
| SIGNATURE EFFECTS | Sound Level Records (Blast) |
| | Light Reduction (Smoke and Haze) |
| | * Visual Light Emission (Flash) |
| | Ejection Patterns |
| STABILITY | Stability of Bipod Legs |
| | Stability of Tripod Mount |
| | Stability of Vehicle Mount |

* Denotes most important MOE

RETROGRADE OPERATIONS RATIONALE

Necessary to compile and compute other data

Best overall measure of accuracy as all data are considered

Necessary for pattern analysis and suppressive fire data

Necessary data in 2-weapon comparison of sustained rate of fire

Necessary data in 2-weapon comparison of rapid rate of fire

Necessary data in 2-weapon comparison of point fire accuracy

---

Not as important as gunner will wait until target is fully exposed

Important measure as it relates to mission accomplishment at the maximum effective ranges

Necessary to ascertain exact rate of fire and provides information on recoil and possible aiming problems at maximum ranges

Most important measure as range has greatest effect on firing

Not too important due to nature of retrograde operations

If excessive will reduce overall responsiveness at longer ranges

---

Provides reliable information on the potential staying power of the candidate weapon during retrograde operations

---

Necessary data for 2-weapon comparison; affects rate of fire

Necessary data for 2-weapon comparison when firing at maximum ranges

Necessary data for 2-weapon comparison when firing at maximum ranges

Most important indicator of weapon reliability at maximum ranges

Necessary data but not too critical due to range unless very excessive

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Not applicable

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Most likely to disclose retrograde firing position/emplacement

Necessary data for 2-weapon comparison

---

Can be measured but MG will normally be tripod-mounted

The stability of the tripod mount and its effect on accurate long-range fires can best be measured during retrograde operations

The stability of the tripod mount and its effect on accurate long-range fires can best be measured during reconnaissance operations

---

RETROGRADE OPERATIONS
DETAILED RATIONALE

| | |
|---|---|
| ACCURACY | Hit probabilities per trigger pull measure the overall effectiveness of the individual/crew weapon's long-range fire capability which is necessary in the conduct of retrograde operations. |
| RESPONSIVENESS | Time to shift fire is the best measure of responsiveness for retrograde operations as the smallest error in the firing sequence will preclude a target hit. |
| SUSTAINABILITY | Retrograde operations are characterized by long-range and close defensive fires increasing in volume. Any measurement of potential staying power is most important. |
| PORTABILITY AND COMPATIBILITY | Each candidate weapon must be closely evaluated to detect any hindrance caused by the weapon in regard to movement since retrograde operations are characterized by rapid withdrawal. |
| SIGNATURE EFFECTS | The measurement of visual light emission is the most important as a position/emplacement disclosing effect during the conduct of retrograde operations. |
| STABILITY | The overall effect of stability to long-range fires can best be measured during the conduct of retrograde operations. |

## APPENDIX 4 TO ANNEX G

## FIRE AND MANEUVER, COMBAT FLOW CHART

| Combat Action | Individual/Crew Action | Characterized by |
| --- | --- | --- |
| Fire and Maneuver (The maneuver element uses fire and movement to advance) | Occupy positions to best assist the advance of the rifle squads, provide an accurate heavy volume of fire to gain and maintain fire superiority. | Alert movement, as far for ward as possible, prompt delivery of fire when required. |

"Maneuver Element. When the gun crews accompany the maneuver element, the following procedures are employed. (1) Gun crews take positions, with or protecting the forma tion, which afford the best opportunity for prompt delivery of fire should resistance be encountered en route to the objective. When the terrain is rugged and favors suct action the gun(s) may advance by bounds from position to position. Where flat terrai affords no favorable gun position, the crew(s) move in rear and toward the flank(s) c the rifle element prepared for prompt action. In such cases, a new potential positic should be selected by the gun crew leader as each previously selected position is passed. Where overhead fire is impracticable position(s) on the flanks of the rifle elements favors fire support by delaying masking of fire by the advance." FM 23-67, para 132b.

| CATEGORY | MANEUVER ELEMENT MEASURES OF EFFECTIVENESS |
|---|---|
| ACCURACY | Number of Hits<br>* Hit Probability Per Trigger Pull<br>Distribution of Near Misses<br>Hit Probability in Sustained Rate of Fire<br>Hit Probability in Point Fire (Aperture) |
| RESPONSIVENESS | Time to First Round<br>Time to First Hit<br>Time Between Bursts<br>* Time to Shift Fire<br>Time Between Hits<br>Sight Manipulation Time |
| SUSTAINABILITY | * Hits Per Pound as Percent of Basic Load |
| RELIABILITY | Time to Load (Reload)<br>Time to Clear Malfunctions/Stoppages<br>Time Between Malfunctions/Stoppages<br>* Number of Rounds Between Malfunctions/Stoppages<br>Time to Change Barrel |
| PORTABILITY AND COMPATIBILITY | Movement Times<br>Crew Drill Times<br>Prepare and Camouflage Positions/Emplacements<br>Compatibility with Other Items of Equipment<br>Ease of Handling During Movement (Hot/Cold)<br>Clear Fields of Fire<br>Conduct Recon of withdrawal routes<br>Time Required to Change Position<br>Ease of Maintaining Readiness Posture |
| SIGNATURE EFFECTS | Sound Level Records (Blast)<br>Light Reduction (Smoke and Haze)<br>Visual Light Emission (Flash)<br>Ejection Patterns |
| STABILITY | Stability of Bipod Legs<br>Stability of Tripod Mount<br>Stability of Vehicle Mount |

* Denotes most important MOE

FIRE AND MANEUVER (MANEUVER ELEMENT)

RATIONALE

---

Necessary to compile and compute other data
Best overall measure of accuracy as all data are considered
Necessary for pattern analysis and suppressive fire data
Necessary data for 2-weapon comparison of sustained rate of fire
Necessary data for 2-weapon comparison of rapid rate of fire
Necessary data for 2-weapon comparison of point fire accuracy

---

Firer may not be in position to engage target on initial exposure
Important measure of mission accomplishment
Necessary to ascertain exact rate of fire
Most important measure of weapon responsiveness for the fire support element
Important measure of mission accomplishment
If excessive will reduce overall responsiveness of the maneuver element

---

Provides reliable information on the potential staying power of the candidate weapons as part of the maneuver element

---

Necessary data for 2-weapon comparison; affects rate of fire
Necessary data for 2-weapon comparison; affects rate of fire
Necessary data for 2-weapon comparison; affects rate of fire
Most important indicator of weapon reliability
If excessive may prevent maintaining of fire superiority

---

Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Not applicable
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Not applicable
Not applicable
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison

---

Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison

---

Necessary data for 2-weapon comparison
Normally not employed with maneuver element
Necessary data for 2-weapon comparison

---

FIRE AND MANEUVER (FIRE SUPPORT ELEMENT)
DETAILED RATIONALE

| | |
|---|---|
| ACCURACY | Hit probability per trigger pull measures the overall effectiveness of the individual/crew weapon combination for all target engagements regardless of range, position, or cyclic rate of fire. The second most important measure is the distribution of near misses as this will determine the suppressive fire effects against targets on the objective. |
| RESPONSIVENESS | Time to shift fire is the best measure of responsiveness for the individual/crew weapon combination as part of the maneuver element as it is an indicator of ease of handling, and the gunner must shift fire rapidly to engage surprise targets and maintain fire superiority. |
| SUSTAINABILITY | In the maneuver element where ammunition is limited to that carried, the per cent of basic load required to accomplish a hit or gain fire superiority becomes critical. |
| RELIABILITY | The number of rounds between malfunctions/stoppages as well as the type of stoppages (correctable or terminal) are most important in this combat action, as a terminal stoppage of the machine gun(s) of the maneuver element could result in the immediate loss of fire superiority over the enemy. |
| PORTABILITY AND COMPATIBILITY | Each candidate weapon must be closely evaluated to detect any hindrance caused by the weapon in regard to alert movement, immediate occupation of firing positions, and the prompt delivery of supporting fires required while during fire and maneuver. |
| SIGNATURE EFFECTS | Any position disclosing effect is critical to the maneuver element conducting the fire and movement required to accomplish its mission. These positions are hastily selected and therefore vulnerable to enemy fire. |
| STABILITY | The stability of the various mounts will be limited to testing the bipod and vehicle mounts during this combat action. |

APPENDIX 5 TO ANNEX G

FIRE AND MANEUVER, COMBAT FLOW CHART

| Combat Action | Individual/Crew Action | Characterized by |
|---|---|---|
| Fire and Maneuver (Fire support element) | Provide riflemen with an accurate heavy volume of supporting fire, assure continuous fire support by rapid displacement when necessary | Medium to short range sustained fire, anticipated rapid displacement by individual/crew weapon combination |

"Fire Support Element. Gun crews, which are part of the platoon support element, employ the following procedures to support the attack. (1) The machine guns set up, under the control of the weapons squad leader, in positions which offer observation, good fields of fire, cover, and concealment. (2) The squad leader specifies the method and rate of fire to be used in engaging targets. Sufficient fire is placed on targets to neutralize them, but consideration is given to conserving ammunition for other targets which may appear during the attack. (3) The squad leader anticipates the masking of fire and displaces the weapons by crews. In the absence of a leader, the gunners are responsible for displacement." FM23-67 para 132a.

| CATEGORY | FIRE SUPPORT ELEMENT MEASURES OF EFFECTIVENESS |
|---|---|
| ACCURACY | Number of Hits<br>* Hit Probability Per Trigger Pull<br>Distribution of Near Misses<br>Hit Probability in Sustained Rate of Fire<br>Hit Probability in Rapid Rate of Fire<br>Hit Probability in Point Fire (Aperture) |
| RESPONSIVENESS | Time to First Round<br>Time to First Hit<br>Time Between Bursts<br>* Time to Shift Fire<br>Time Between Hits<br>Sight Manipulation Time |
| SUSTAINABILITY | * Hits per Pound as Percent of Basic Load |
| RELIABILITY | Time to Load (Reload)<br>Time to Clear Malfunctions/Stoppages<br>Time Between Malfunctions/Stoppages<br>* Number of Rounds Between Malfunctions/Stoppages<br>Time to Change Barrel |
| PORTABILITY AND COMPATIBILITY | Movement Times<br>Crew Drill Times<br>Prepare and Camouflage Positions/Emplacements<br>Compatibility with Other Items of Equipment<br>Ease of Handling During Movement (Hot/Cold)<br>Clear Fields Of Fire<br>Conduct Recon of withdrawal Routes<br>Time Required to Change Position<br>Ease of Maintaining Readiness Posture |
| SIGNATURE EFFECTS | Sound Level Records (Blast)<br>Light Reduction (Smoke and Haze)<br>Visual Light Emission (Flash)<br>Ejection Patterns |
| STABILITY | Stability of Bipod Legs<br>Stability of Tripod Mount<br>Stability of Vehicle Mount |

* Denotes most important MOE

## FIRE AND MANEUVER (FIRE SUPPORT ELEMENT)
### DETAILED RATIONALE

| | |
|---|---|
| ACCURACY | Hit probabilities per trigger pull measure the overall effectiveness of the individual/crew weapon's supporting fire capability which is of paramount importance during the conduct of fire and maneuver. |
| RESPONSIVENESS | Time to shift fire is the most important measure of effectiveness in the combat action, fire and maneuver, as due to the masking effect of the advancing troops, fire will always be shifted by the gunners of the fire support element. |
| SUSTAINABILITY | Since the combat action, fire and maneuver (fire support element) is characterized by a heavy volume of supporting fires, it is essential that the potential staying power of the individual/crew weapon's system be measured. |
| RELIABILITY | In the fire support element where a heavy volume of supporting fires is required, the most important measure of reliability is the number of rounds between malfunctions/stoppages. |
| PORTABILITY AND COMPATIBILITY | Each candidate weapon must be closely evaluated to detect any hindrance caused by the weapon in regard to movement since once fires on the objective are masked the fire support element must displace rapidly. |
| SIGNATURE EFFECTS | The most important position-disclosing effect would be light reduction in that the firing position would by necessity have little or no preparation. |
| STABILITY | The overall effect of stability of heavy volumes of supporting fires can best be measured during the combat action, fire and movement. |

## FIRE AND MANEUVER (FIRE SUPPORT ELEMENT)
### RATIONALE

---

Necessary to compile and compute other data

Best overall measure of accuracy as all data are considered

Necessary for pattern analysis and suppressive fire data

Necessary data for 2-weapon comparison of sustained rate of fire

Necessary data for 2-weapon comparison of rapid rate of fire

Necessary data for 2-weapon comparison of point fire accuracy

---

Necessary to compile and compute other data

Important measure as it relates directly to mission accomplishment

Necessary to ascertain exact rate of fire

Most important measure as fire will always be shifted in this combat action

Main indicator of time required to accomplish mission

Indicator of time required to accomplish mission

---

Provides reliable information on the per cent of basic load required for mission accomplishment while supporting the platoon attack

---

Necessary data for 2-weapon comparison; affects rate of fire

Necessary data for 2-weapon comparison while supporting the attack

Necessary data for 2-weapon comparison while supporting the attack

Most important indicator of weapon reliability

Necessary data for 2-weapon comparison and if excessive could become critical to mission accomplishment

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Not applicable

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Not applicable.

Necessary data for 2-weapon comparison

Not applicable

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Most important due to heavy volume of fire from hastily selected firing position

Necessary data for 2-weapon comparison

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

---

## APPENDIX 6 TO ANNEX G

## ADVANCE TO CONTACT, COMBAT FLOW CHART

| Combat Action | Individual/Crew Actions | Characterized By |
| --- | --- | --- |
| Advance to Contact | Alert movement, rapid reaction immediate return of fire, provide supporting fires for attack. | Anticipated medium to short range enemy contact, rapid situation estimates, aggressive actions to prevent delay of column. |

"Advancing units move from the assembly area in a column formation. The machine gunners are located in the platoon formation where they can best deploy themselves into an assault formation or separate themselves from the column and support by fire." (Chapter 9, FM 23-60.)

| CATEGORY | ADVANCE TO CONTACT MEASURES OF EFFECTIVENESS |
|---|---|
| ACCURACY | Number of Hits<br>* Hit Probability Per Trigger Pull<br>Distribution of Near Misses<br>Hit Probability in Sustained Rate of Fire<br>Hit Probability in Point Fire (Aperture) |
| RESPONSIVENESS | Time to First Round<br>* Time to First Hit<br>Time Between Bursts<br>* Time to Shift Fire<br>Time Between Hits<br>Sight Manipulation Time |
| SUSTAINABILITY | * Hits per Pound as per cent of Basic Load |
| RELIABILITY | Time to Load (Reload)<br>Time to Clear Malfunctions/Stoppages<br>Time Between Malfunctions/Stoppages<br>* Number of Rounds Between Malfunctions/Stoppages<br>Time to Change Barrel |
| PORTABILITY AND COMPATIBILITY | Movement Times<br>Crew Drill Times<br>Prepare and Camouflage Positions/Emplacements<br>Compatibility with Other Items of Equipment<br>Ease of Handling During Movement (Hot/Cold)<br>Clear Fields of Fire<br>Conduct Recon of withdrawal Routes<br>Time Required to Change Position<br>* Ease of Maintaining Readiness Posture |
| SIGNATURE EFFECTS | Sound Level Records (Blast)<br>Light Reduction (Smoke and Haze)<br>Visual Light Emission (Flash)<br>Ejection Patterns |
| STABILITY | Stability of Bipod Legs<br>Stability of Tripod Mount<br>* Stability of Vehicle Mount |

* Denotes most important MOE

ADVANCE TO CONTACT
RATIONALE

---

Necessary to compile and compute other data

Best overall measure of accuracy as all data are considered

Necessary for pattern analysis and suppressive fire data

Necessary data for 2-weapon comparison of sustained rate of fire

Necessary data for 2-weapon comparison of rapid rate of fire

Necessary data for 2-weapon comparison of point fire accuracy

---

Necessary data for 2-weapon comparison - affects probability of individual/crew survivability

One of two important measures of mission accomplishment

Necessary to obtain exact rate of fire and provides information on recoil and aiming problems if quick response is required

One of two important measures of mission accomplishment

Not as important due to nature of advance to contact

Not as important due to nature of advance to contact

---

Provides reliable information on the per cent of basic load required for mission accomplishment while conducting an advance to contact

---

Necessary data for 2-weapon comparison - affects rate of fire

Necessary data for 2-weapon comparison during a quick-response situation

Necessary data for 2-weapon comparison during a quick-response situation

Most important indicator of weapon reliability during a quick-response situation

Becomes more critical as gun target distance decreases or barrel change time increases

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Not applicable

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Not applicable

Not applicable

Necessary data for 2-weapon comparison

Most important measure in the quick-response situation

---

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

Necessary data for 2-weapon comparison

---

Not applicable

Not applicable

Most likely only mount in use during a quick-response situation

---

ADVANCE TO CONTACT
DETAILED RATIONALE

| | |
|---|---|
| ACCURACY | Hit probabilities per trigger pull measure the overall effectiveness of the individual/crew weapon combination on all target engagements fired regardless of range or cyclic rate of fire. |
| RESPONSIVENESS | The time to first hit is one of two important measures in the combat action, advance to contact, which is characterized by rapid reaction to short range enemy fires, as it is the chief indicator of mission accomplishment.<br><br>The other important measure is the time to shift fire as it is an indicator of ease of handling and the gunner's ability to accomplish his mission. |
| SUSTAINABILITY | In the advance to contact, where rapid reaction is vital and ammunition is limited to that carried, the per cent of basic load required to accomplish each mission becomes critical |
| RELIABILITY | The number of rounds between malfunctions/stoppages is the basic measure which will determine the probability that a burst of fire will be fired for each trigger pull and as such is the main indicator of weapon reliability. |
| PORTABILITY AND COMPATIBILITY | The combat action, advance to contact, requires alert movement and rapid reaction to enemy fire, which forces the individual/crew combination to carry the weapon at the ready for extended periods of time. Therefore, the measurement, ease of maintaining readiness posture, is most important in this combat action. |
| SIGNATURE EFFECTS | In the combat action, advance to contact, fire is initiated by the enemy in most cases so any position-disclosing signature effects are relatively unimportant but should be measured for a 2-weapon comparison. |
| STABILITY | The opportunity to measure stability in the combat action, advance to contact, is limited to the vehicle mount. |

## APPENDIX 7 TO ANNEX G

## COMBAT IN CITIES, COMBAT FLOW CHART

| Combat Action | Individual/Crew Actions | Characterized by |
|---|---|---|
| Combat in Cities | Large volume of aimed covering fire, rapid restricted movement well forward with engagements at medium to short range. | Restricted observation and fields of fire, medium to short range grazing fire into selected areas and at targets of opportunity. |

"The machine guns of the rifle platoon are employed initially to provide covering fire for the rifle squad during its attack to seize a platoon foothold in the area. Once a foothold is secured, the machine guns are quickly moved into the built-up area and kept well forward in the platoon where they can provide supporting fire for the platoon's attack. Machine gunners are prepared to deliver grazing fire down streets, alleys and other open area. These fires destroy any enemy driven into the open and prevent them from using streets, alleys and open areas as routes for supply, reinforcement or maneuver." FM 23-67, para 135a(2)

| CATEGORY | COMBAT IN CITIES MEASURES OF EFFECTIVENESS |
|---|---|
| ACCURACY | Number of Hits<br>* Hit Probability Per Trigger Pull<br>Distribution of Near Misses<br>Hit Probability in Sustained Rate of Fire<br>Hit Probability in Rapid Rate of Fire<br>Hit Probability in Point Fire (Aperture) |
| RESPON-SIVENESS | Time to First Round<br>Time to First Hit<br>Time Between Bursts<br>* Time to Shift Fire<br>Time Between Hits<br>Sight Manipulation Time |
| SUSTAIN-ABILITY | * Hits Per Pound as Per Cent of Basic Load |
| RELI-ABILITY | Time to Load (Reload)<br>Time to Clear Malfunctions/Stoppages<br>Time Between Malfunctions/Stoppages<br>* Number of Rounds Between Malfunctions/Stoppages<br>Time to Change Barrel |
| PORTABILITY AND COMPATIBILITY | Movement Times<br>Crew Drill Times<br>Prepare and Camouflage Positions/Emplacements<br>Compatibility with Other Items of Equipment<br>Ease of Handling During Movement (Hot/Cold)<br>Clear Fields of Fire<br>Conduct Recon of withdrawal Routes<br>Time Required to Change Position<br>Ease of Maintaining Readiness Posture |
| SIGNATURE EFFECTS | Sound Level Records (Blast)<br>Light Reduction (Smoke and Haze)<br>* Visual Light Emission (Flash)<br>Ejection Patterns |
| STABILITY | Stability of Bipod Legs<br>Stability of Tripod Mount<br>Stability of Vehicle Mount |

* Denotes most important MOE

RATIONALE

Necessary to complete and compute other data
Main indicator of individual/crew combination total accuracy
Necessary for pattern analysis and suppressive fire data
Necessary data for 2-weapon comparison of sustained rate of fire
Necessary data for 2-weapon comparison of sustained rapid rate of fire
Necessary data for 2-weapon comparison of point fire accuracy

---

Necessary to compile and compute other data
Necessary to compile and compute other data
Necessary to obtain exact rate of fire and to compute other data
Main indicators of weapon responsiveness in combat in cities
Not as important due to nature of combat in cities
Not as important due to nature of combat in cities

---

Provides reliable information on the per cent of basic load required for mission accomplishment while participating in combat in cities

---

Necessary data for 2-weapon comparison; affects rate of fire
Necessary data for 2-weapon comparison; affects rate of fire
Necessary data for 2-weapon comparison; affects rate of fire
Most important indicator of weapon reliability
If excessive could disrupt the necessary large volume of aimed covering fire

---

Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Not applicable
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison
Not applicable
Not applicable
Necessary data for 2-weapon comparison
Necessary data for 2-weapon comparison

---

Important from firer standpoint since firing may be from inclosed areas
The light reduction signature effect will be more noticeable in restricted areas
The visible signature effect will be more noticeable in restricted areas
Necessary data for 2-weapon comparison

---

Will test bipod legs from various firing positions
Tripod will be used for initial covering fire only
Necessary data for 2-weapon comparison

COMBAT IN CITIES
DETAILED RATIONALE

| | |
|---|---|
| ACCURACY | Hit probability per trigger pull measures the overall effectiveness of the individual/crew weapon combination regardless of the mission, large volume covering fire or grazing fire, range, or cyclic rate of fire. |
| RESPONSIVENESS | The time to shift fire is the most important measure in the combat action, combat in cities, as the gunner will be required to shift up and down (to fire from or into windows) as well as left and right in order to engage enemy targets. |
| SUSTAINABILITY | The number of rounds fired per engagement will measure basic load life expectancy when utilized in the city combat environment. |
| RELIABILITY | The number of rounds between malfunctions/stoppages is the basic measure which will determine the probability that a burst of fire will be fired for each trigger pull and as such is the main indicator of weapon reliability. |
| PORTABILITY AND COMPATIBILITY | The rapid displacement and forward position of the machine gun during combat in cities facilitates the collection of most MOE required to evaluate portability and compatibility. |
| SIGNATURE EFFECTS | Flash will attract the attention of enemy forces in buildings more rapidly than noise in city combat. |
| STABILITY | Stability of the bipod legs will be subjected to firing from various surfaces (e.g., concrete, bricks, rubble, window sills). |

ANNEX N

MATRIX

| CATEGORY | MEASURES OF EFFECTIVENESS* | COMBAT ACTIONS: Deliberate Defense | Hasty Defense | Retrograde Operations | Fire and Maneuver | Fire and Movement | Advance to Contact | Combat in Cities | Individually Important | Time Collected | Possible Occurrence | Most Appropriate Range on Which to Collect | TSAIB Range Most Suitable* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACCURACY | Number of Hits | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | A/D | D |
| | Hit Probability Per Trigger Pull | XYZ* | XYZ* | XYZ* | XYZ* | XYZ* | XYZ* | XYZ* | ? | ? | ? | A/D | D |
| | Distribution of Near Misses | Z | Z | Z | Z | Z | Z | Z | 0 | ? | ? | Q | Q |
| | Hit Probability in Sustained Rate of Fire | XYZ | XYZ | XYZ | XYZ | XYZ | [illegible] | XYZ | 0 | ? | ? | A/D | D |
| | Hit Probability in Rapid Rate of Fire | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | A/D | D |
| | Hit Probability in Point Fire | | | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | A/D | D |
| RESPONSIVENESS | Time to First Round | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | Q | Q |
| | Time to First Hit | YZ | YZ | YZ | YZ | YZ | YZ* | YZ | 1 | ? | ? | Q | Q |
| | Time Between Bursts | YZ | YZ | YZ | YZ | YZ | YZ | YZ | 0 | ? | ? | A/D | D |
| | Time to Shift Fire | YZ* | YZ | YZ* | YZ* | YZ* | YZ° | YZ* | 6 | ? | ? | A/D | D |
| | Time Between Hits | YZ | YZ* | YZ | YZ | YZ | YZ | YZ | 1 | ? | ? | A/D | D |
| | Sight Manipulation Time | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | A/D | D |
| SUSTAINABILITY | Hits Per Pound as Per Cent of Basic Load | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | ? | ? | ? | A/D | D |
| RELIABILITY | Time to Load (Reload | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | A/D | D |
| | Time to Clear Malfunctions/Stoppages | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | C | ? | ? | A/D | D |
| | Time Between Malfunctions/Stoppages | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | A/D | D |
| | Number of Rounds Between Malfunctions Stoppages | XYZ* | XYZ* | XYZ* | XYZ* | XYZ* | XYZ* | XYZ* | ? | ? | ? | A/D | D |
| | Time to Change Barrel | XYZ | X | XYZ | XYZ | XYZ | XYZ | XYZ | 0 | ? | ? | A/D | D |
| PORTABILITY AND COMPATIBILITY | Movement Times | XJ | XJ | XJ | XJ | XJ | XJ | XJ | 0 | ? | ? | A/Q | D |
| | Crew Drill Times | XJ | XJ | XJ | XJ | XJ | XJ | XJ | 0 | ? | ? | NA | NA |
| | Prepare and Camouflage Positions/Replacements | XJ | XJ | XJ | | | | | 0 | 3 | ? | A/D | D |
| | Compatibility with Other Items of Equipment | XJ | XJ | XJ | XJ | XJ | XJ | XJ | 0 | ? | ? | A/Q | D |
| | Ease of Handling During Movement (Hot/Cold) | XJ | XJ | XJ | XJ | XJ | XJ | XJ | 0 | ? | ? | A/Q | D |
| | Clear Fields of Fire | XJ | XJ | XJ | XJ | XJ | XJ | XJ | 0 | 4 | ? | A/D | D |
| | Conduct Recon of w/d Routes | | | | XJ* | | | | 1 | 1 | ? | D | D |
| | Time Required to Change Position | XJ | XJ | XJ | XJ | XJ | XJ | XJ | 0 | [illegible] | ? | A/D | D |
| | Ease of Maintaining Readiness Posture | | | | | XJ | XJ* | XJ | 1 | 3 | ? | A/Q | Q |
| SIGNATURE EFFECTS | Sound Level Records (Blast) | XJ | XJ | XJ | XJ | XJ | XJ | XJ | 0 | ? | ? | A/D | D |
| | Light Reduction (Smoke and Haze) | XJP (H&S) | XJP (H&S)* | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S)* | 2 | ? | ? | A/D | D |
| | Visual Light Emission (Flash) | XJP (H&S)* | XJP (H&S) | XJP (H&S)* | XJP (H&S)* | XJP (H&S) | XJP (H&S) | XJP (H&S) | 3 | ? | ? | A/D | D |
| | Ejection Patterns | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | 0 | ? | ? | A/D | D |
| STABILITY | Stability of Bipod Legs | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | | XJP (H&S) | 0 | 6 | ? | A/D | D |
| | Stability of Tripod Mount | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | | | XJP (H&S) | 0 | 5 | ? | A/D | D |
| | Stability of Vehicle Mount | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | XJP (H&S) | 0 | ? | ? | A/D | D |

*All studies conducted and conclusions derived from this matrix were made through consideration of the actions of the individual/crew weapon combination in each combat action and not the leader's or unit's actions in the various combat actions.

## APPENDIX 1 TO ANNEX H

### LEGEND

A. Attack Range

D. Defense Range

Q. Quick-fire Range

P. Photography, Motion (M), Still (S)

J. Judgement

Based on project officer evaluation, observation, and test soldier comments.

X. Stop Action

First-generation state-of-the-art, manual data, collection, processing and reduction; time consuming and realistic. Measurements are made by stopwatch, ruler, and round count.

Y. Partial Instrumentation

Second-generation data collection, current degree of instrumentation; collection is instrumented; however, processing is primarily manual with minor machine calculation.

Z. Total Instrumentation

Third-generation, automatic data collection, processing, and reduction.

* Most Important Measurement

The letters X, Y, and Z are indicators of the level of instrumentation available, with which to collect and process data on the various measures of effectiveness (MOE).

APPENDIX 2 TO ANNEX H

LEVEL OF INSTRUMENTATION

1. The use of "X" instrumentation does not afford USAIB any new measures of effectiveness in weapons testing over that provided by "Y" instrumentation. However, "Z" instrumentation does provide new data collection techniques that will enhance combat realism in testing and greatly reduce the present ammount of real time required to process the collected data.

2. For example, during Quick-fire Experiment I, conducted by USAIB using "Y" instrumentation, 20 test days were required to collect the actual data. A data base of 4000 rounds was collected. Time required to reduce these data to meaningful information, even using a time share computer, was 72 man weeks.* Using "Z" instrumentation, these data could have been recorded and reduced on a continuous daily basis that would have enabled all data to be interpreted into meaningful information within 5 man-weeks** after completion of the test firing.

3. The instrument ranges provide two facets to test results previously lacking. Initially, with information being collected on each round fired, the cost of testing can be reduced. For example, the type small arms ammunition being considered for use in new weapons is now being handmade today at $1.70 per round. If a test were conducted with this type ammunition, the amount available would probably be very small, perhaps 1000 rounds at a total cost of $1,700. Under old testing methods only hits and rounds fired could be measured. Therefore, with an .08 hit probability, typical of operational hit probabilities, only 80 rounds out of 1000 would be measured requiring much expense to accumulate a satisfactory data base. However, nearly 1000 our of 1000 rounds could be measured and correlated using the scientific methods thus far developed at the Infantry Board. Secondly, as current weapon development seems to be directed at small, rather than major, improvements on present weaponry, small differences can now be measured that will discriminate between two seemingly similar weapons systems thereby providing more objective results which will aid the decision-makers in their selection of competing weapons.

* Six scientific and engineering personnel working 12 weeks and $3,400 worth of time share computer time.

** Five scientific and engineering personnel working 1 week.

4. Current USAIB policy requires final test report submission 22 working days from the end of physical testing. From this the validity of the requirement for "Z" instrumentation is readily apparent.

## APPENDIX 3 TO ANNEX H

## DISCUSSION OF REQUIRED FACILITIES

1. General.

a. The present attack and quick-fire facilities and the approved instrumented defense facility provide realistic combat-type situations wherein all measurements can be taken in real-time through instrumentation and do not interrupt testing which would be unrealistic. However, these test facilities were designed and constructed to test rifles and, as such, do not allow for the increased range, volume of fire and freedom of movement required for the realistic testing of machine guns.

b. Of the three instrumented test facilities, the defense facility alone presents the best situation for modification with which to handle machine gun testing. The addition of more targets at greater ranges (longest distance now planned on defense facility is 450 meters) could create a realistic situation for the testing of candidate machine guns.

c. Each of the instrumented facilities will be discussed below as to what it can provide in the way of machine gun testing.

2. Attack Facility.

a. The instrumented attack facility was designed to place an individual test soldier in a realistic combat attack role and is most beneficial in determining the portability and compatibility characteristics of the man/weapon combination in the attack at ranges up to 350 meters.

b. "In an attack the mission of the machine gunner is to assist the advance of the rifleman with supporting fire, including close up fire support, during the assault." (FM 23-67, paragraph 130b). Employment of the machine guns and their heavy volume of direct fire depends on several considerations, which include: (1) the distance from the LD to the objective; (2) observation and fields of fire from the LD over the route(s) to the platoon objective; and (3) availability of firing positions forward of the LD.

c. Current tactical employment of the two machine guns in the rifle platoon allows the rifle platoon leader three separate courses of action dependent upon the terrain and the combat situation. These choices are:

(1) Both machine guns support by fire from the vicinity of the LD.
(2) Both machine guns accompany the maneuvering element.
(3) A combination of 1 and 2 by separating the guns.

All three of these situations must be available for the testing of the candidate machine guns.

d. The present attack facility does not afford but one course of action due to the terrain on which it is constructed and that course is for both guns to accompany the maneuvering element.

3. Quick-fire Facility.

a. The instrumented quick-fire facility was designed to place an individual test soldier in a realistic quick-reaction situation wherein the test soldier must deal with a surprise enemy threat. The range facilitates the timing of the reaction of a man/weapon combination in various firing modes, ranges, and angles of fire. This in turn provides the most valid data from which to determine the quick-reaction responsiveness discriminators of the man/weapon combination.

b. The results of machine gun firing can and have been recorded on the present instrumented quick-fire facility. However, the heavy volume of fire tends to tear up the range facility excessively by severing control and power wires and tearing up target frames and sand bags. For example, eight rounds with machine guns fired as much ammunition as 20 runs with rifles (2,000 rounds), and inflicted considerably more damage on the range facility.

c. The machine gun could and should be tested in the quick-reaction situation but on a specially constructed range that can withstand the heavy volume of force.

4. Defense Facility.

a. The instrumented defense facility is being constructed to place the individual test soldier in a realistic combat defensive situation.

b. The facility in its present configuration can not test the long-range fire characteristics of the machine gun which can place effective fire on enemy targets at ranges out to 1100 meters. The longest range now available on the defense range is 450 meters. The terrain is suitable for the adding of additional targets at ranges from 450 meters out to 1100 meters.

c. The placement of additional targets at greater ranges and the constructing of new firing positions from which to fire supporting fires for the attack can make the instrumented defense facility suitable, if not ideal, for the testing of machine guns.

APPENDIX 4 TO ANNEX H

PROPOSED MACHINE GUN RANGE

1. GENERAL. Any tests of candidate machine guns must be conducted on a reliable instrumented facility on which the two weapons can be realistically compared. The most ideal facility is one that provides the following:

a. Sufficient terrain on which to maneuver the tactical unit (platoon, squad, fire team or recon section) to which the candidate weapons are normally assigned.

b. The ranges and safety fans necessary to test the maximum effective range of the candidate weapons.

c. Moving vehicular and personnel target system.

d. Assault firing positions, overhead firing positions and position defilade firing positions.

2. DISCUSSION. The facility and terrain shown in Figure H.1 do not represent any particular piece of terrain at Fort Benning; Figure H.1 is merely a sketch of what an ideal machine gun range should look like.

a. The range is designed to test the following combat actions:

(1) Deliberate Defense.

(2) Hasty Defense.

(3) Retrograde Operations.

(4) <u>Fire</u> and Maneuver.

(5) Fire and <u>Maneuver</u>.

(6) Advance to Contact.

This accounts for 6 of 7 selected combat actions; Combat in Cities is omitted.

b. The firing points were selected for the following reasons:

(1) Firing Point A-B. Positions along this line can be used to conduct the long-range firing of Retrograde Operations and the heavy volume of fire required in the firing element of Fire and Maneuver.

(2) Firing Point C-D. Positions along this line can be used to fire the defensive fires necessary for both the Deliberate and Hasty Defense, dependent upon the type of prepared firing position; in addition, these same positions can also be used as an initial point for <u>Fire</u> and Maneuver.

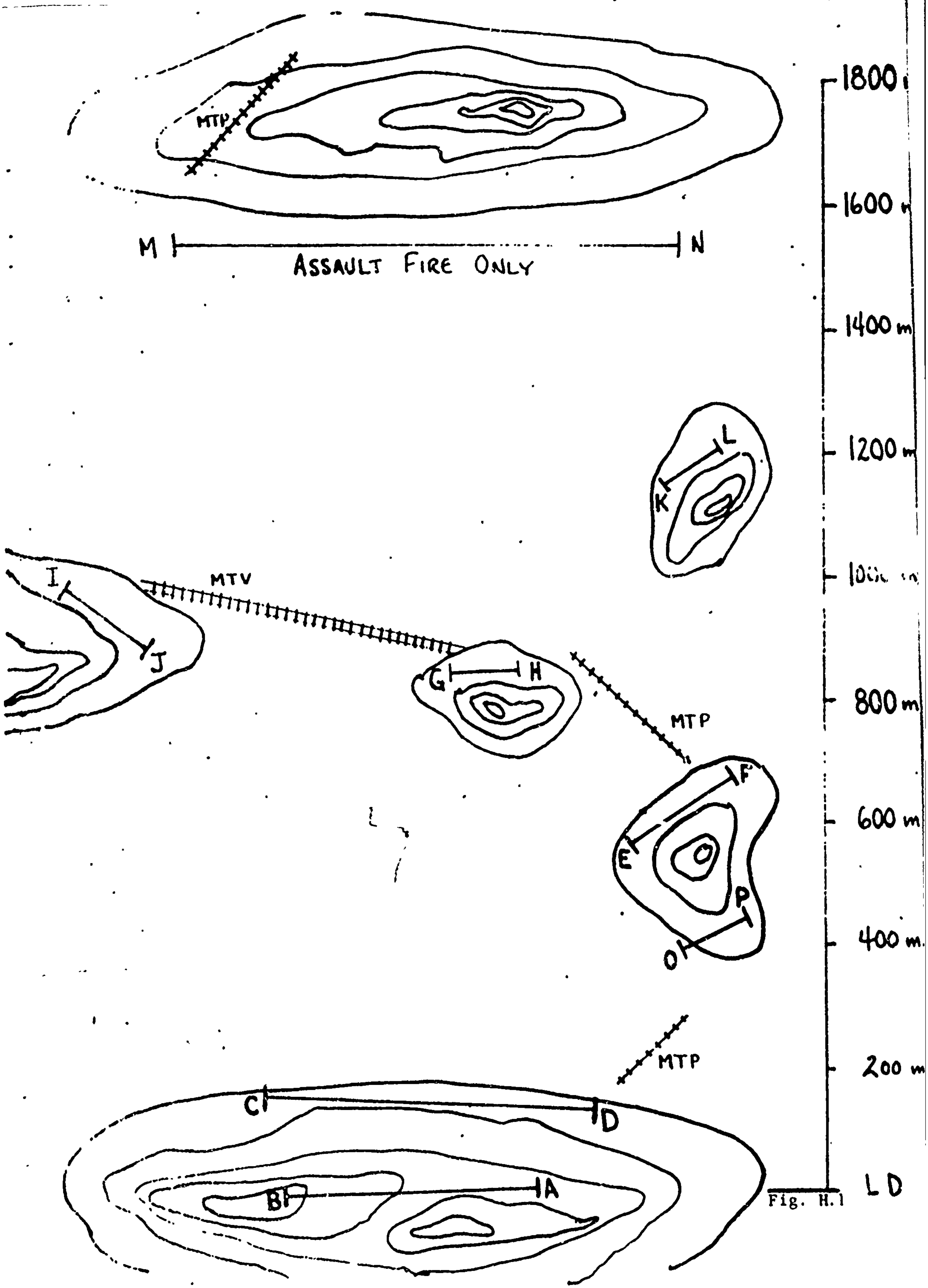
(3) Firing Points E-F, G-H, I-J and K-L. Positions along these lines can be used for Fire and Maneuver, Retrograde Operations, Hasty Defense and Advance to Contact.

(4) Firing Point M-N. Positions along this line can be used for the assault role of the machine gun while conducting Fire and Maneuver.

(5) Firing Point O-P. Positions along this line can be used for position defilade firing as required.

c. Moving targets have been placed on the range: MTV (moving target vehicle) and MTP (moving target personnel).

d. Testing of the candidate machine guns in the quick-fire role can be accomplished by emplacing appropriate targets along the approaches to firing points K-L, G-H, O-P, and E-F.



MTP
M
N
ASSAULT FIRE ONLY
1800 m
1600 m
1400 m
1200 m
L
K
I
J
MTV
G
H
MTP
800 m
F
600 m
E
P
O
400 m.
MTP
200 m
C
D
B
A
LD


Fig. H.1

ANNEX I

REFERENCES

ARMY SUBJECT SCHEDULES

| | |
|---|---|
| 7-1 | Organization, Mission, Capabilities and Characteristics of the Infantry, Mechanized Infantry and Airborne Battalions |
| 7-2 | Rifle Squad Tactical Training |
| 7-3 | Weapons Squad Tactical Training |
| 7-4 | Ground Surveillance Team and Section, Tactical Training |
| 7-7 | 81-mm Mortar Squad Tactical Training |
| 7-9 | Patrolling |
| 7-10 | Land Navigation |
| 7-11B10 | Changes 1 and 2, MOS Technical Training and Refresher Training of Light Weapons Infantryman--MOS 11B10 |
| 7-11C10 | Changes 1 and 2, MOS Technical Training and Refresher Training of Infantry Indirect-fire Crewman |
| 7-11H10 | Changes 1 and 2, MOS Technical Training and Refresher Training of Infantry Direct-fire Crewman |
| 7-11H30 | MOS Technical Training of Infantry Direct-fire Crewman (ENTAC Antitank Guided Missile Gunner)--MOS11H30 |
| 7-12 | Antiinfiltration and Counterguerrilla Training |
| 7-27 | Heavy Mortar Platoon Tactical Training |
| 7-30 | Rifle Platoon Tactical Exercise |
| 7-31 | Weapons Platoon Tactical Exercise |
| 7-35 | Antitank Platoon Tactical Exercise |
| 7-40 | Rifle Company Tactical Exercise |
| 7-50 | Air Movement Training |

| | |
|---|---|
| 7-51 | Airborne Proficiency |
| 7-53 | Drop Zone Assembly |
| 17-37 | Rifle Squad, Armored Car or Reconnaissance Platoon |
| 21-12 | Survival, Evasion and Escape |
| 21-16 | Antiinfiltration and Guerrilla Warfare Training |
| 21-19 | Field Fortifications |
| 21-20 | Individual Tactical Training |

ARMY TRAINING PROGRAMS

| | |
|---|---|
| 7-4 | Change 1, Infantry, Airborne and Mechanized Division, HHC |
| 7-4-1 | Infantry, Airborne and Mechanized Division |
| 7-15 | Infantry, Airborne Infantry, Airmobile Infantry, Light Infantry and Mechanized Infantry Battalions and Brigades |
| 7-16 | Change 1, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions |
| 7-16-1 | Change 1, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions |
| 7-18 | Rifle Company, Infantry, Airborne, Airmobile and Light Infantry Battalions |
| 7-18-1 | Rifle Company, Infantry, Airborne, and Mechanized Infantry Battalions |
| 7-42 | HHC, Infantry, Airborne, and Mechanized Brigades |
| 7-42-1 | Change 1, HHC, Infantry, Airborne Infantry, Airmobile Infantry, and Mechanized Infantry Brigades |
| 7-47 | Rifle Company, Mechanized Infantry Battalion |
| 7-52 | HHC, Infantry Brigade, Separate |
| 7-56 | HHC, Airmobile and Light Infantry Battalions |

| | |
|---|---|
| 7-58 | Combat Support Company, Airmobile and Light Infantry Battalion |
| 7-157 | Infantry Long Range Patrol Company |
| 7-167 | Infantry Platoon (Scout Dog) (TOE 7-167) |
| 7-168 | Pathfinder Platoons (Sections) (Detachments) |
| 17-18 | Change 1, Air Cavalry Troop (TOE 17-78 and 17-108) |

ARMY TRAINING TESTS

| | |
|---|---|
| 7-15 | Infantry Battalions |
| 7-16-1 | Heavy Mortar Platoon, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions |
| 7-16-3 | Antitank Platoon, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions |
| 7-18 | Change 1, Rifle Company, Infantry and Light Infantry Battalions |
| 7-35 | Airborne Infantry Battalions |
| 7-37 | Rifle Company, Airborne Infantry Battalions |
| 7-45 | Mechanized Infantry Battalion |
| 7-47 | Rifle Company, Mechanized Infantry Battalion |
| 7-55 | Airmobile Infantry Battalion |
| 7-157 | Infantry Long Range Patrol Company |
| 7-168 | Pathfinder Platoon (Section) (Detachment) (TOE 1-56, 1-76, 1-101, 1-256, and 7-168) |
| 17-78 | Air Cavalry Troop of the Armored Cavalry Squadron USAARMS and and Armored Cavalry Regiment |
| 21-4 | Proficiency Test for Infantry AIT |
| 21-2 | Individual Proficiency in Basic Military Subjects |

**FEA PROJECT**

| | |
|---|---|
| 629-5 | Development of Methodology for Evaluating Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers, Dunlap and Associates, May 1963 |

**FIELD MANUALS**

| | |
|---|---|
| 3-8 | Change 1, Chemical Reference Handbook |
| 5-13 | The Engineer Soldier's Handbook |
| 7-11 | Change 1, Rifle Company, Infantry, Airborne and Mechanized |
| 7-15 | Change 1, Rifle Platoon and Squads, Infantry, Airborne and Mechanized |
| 7-20 | Infantry, Airborne Infantry, and Mechanized Infantry Battalions |
| 7-30 | The Infantry Brigades |
| 17-36 | Division Armored and Air Cavalry Units |
| 21-5 | Change 1, Military Training Management |
| 21-41 | Change 1, Soldiers Handbook for Defense Against Chemical and Biological Operations and Nuclear Warfare |
| 21-50 | Ranger Training and Ranger Operations |
| 21-75 | Combat Training of the Individual Soldier and Patrolling |
| 21-76 | Changes 1 and 2, Survival |
| 21-77 | Evasion and Escape |
| 21-150 | Combatives |
| 22-5 | Drill and Ceremonies |
| 22-100 | Military Leadership |
| 23-3 | Techniques of Antitank Warfare |
| 23-5 | US Rifle Caliber .30, M-1 |

| | |
|---|---|
| 23-6 | Changes 1 and 2, Antitank Guided Missile (ENTAC) |
| 23-7 | Changes 1 and 2, Carbine Caliber .30, M-1, M1A1, M2 and M3 (AFM 50-4) |
| 23-8 | Change 1, US Rifle--7.62-mm, M-14 and M14A1 |
| 23-9 | Change 1, Rifle, 5.56-mm, M16A1 |
| 23-11 | Change 2, 90-mm RR Rifle, M67 |
| 23-12 | Technique of Fire of the Rifle Squad and Tactical Application |
| 23-15 | Browning Automatic Rifle, Caliber .30, M1918A2 |
| 23-16 | Change 1, Automatic Rifle Marksmanship |
| 23-23 | Change 1, Antipersonnel Mine M18A1 and M18 (Claymore) |
| 23-30 | Changes 1-3, Grenades and Pyrotechnics |
| 23-31 | Change 1, 40-mm Grenade Launcher, M79 |
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| 31-10 | Denial Operations and Barriers |
| 31-16 | Conterguerrilla Operations |
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| 31-21 | Special Forces Operations--USA Doctrine |
| 31-23 | Stability Operations, USA Doctrine |
| 31-25 | Desert Operations |
| 31-30 | Jungle Training and Operations |
| 31-36 | Night Operations |
| 31-50 | Change 1, Combat in Fortified and Built-up Areas |
| 31-55 | Border Security/Antiinfiltration Operations |
| 31-60 | River Crossing Operations |
| 31-70 | Basic Cold Weather Manual |
| 31-71 | Change 1, Northern Operations |
| 31-72 | Mountain Operations |
| 31-73 | Advisor Handbook for Stability Operations |
| 31-75 | Riverine Operations |
| 57-1 | US Army/US Air Force Doctrine for Airborne Operations (AFM 2-51) |
| 57-35 | Airmobile Operations |
| 57-38 | Pathfinder Operations |

TRAINING CIRCULARS

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| 5-31 | Change 1, VC Boobytraps, Mines, and Mine Warfare Techniques |
| 23-10 | Change 1, 40-mm Grenade Launcher XM148 |
| 23-11 | Starlight Scope Small Hand-held or Individual Weapons Mounted Model No 6060 |

| | |
|---|---|
| 23-12 | Change 1, Target Detection--Crack and Thump Technique |
| 23-13 | Crew Served Weapon Night Vision Sight |
| 23-15 | Engagement of Aerial Targets with Small Arms |
| 23-18 | Night Observation Device, Medium Range (NODMR) |
| 23-20 | M16A1 Rifle Training |
| 23-21 | Familiarization Firing Course: APC M113 with Armament Kit |

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| 8-5-0070-01 | Infantry Weapons Test Methodology Study, Quick-fire Experiment I, June 1969 |
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Infantry Reference Data, USAIS, July 1968

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1. Basic Machinegun Marksmanship, 2. Technique of Machinegun Fire; 3. Predetermined Fire Role of the Machinegun; 4. Tactical Employment of the M-60 Machinegun.

RELATED MATERIAL CONTINUED

U. S. Human Resources Research Office. Division # 4 (Infantry)

CRITICAL COMBAT PERFORMANCES, KNOWLEDGES, AND SKILLS REQUIRED OF THE INFANTRY RIFLE SQUAD LEADER:

#2 - MACHINEGUN, 7.62mm, M60. August 1969.

#13 - DEFENSIVE OPERATIONS. June 1969

#14 - OFFENSIVE OPERATIONS. 26 May 1969

#12 - RETROGRADE OPERATIONS. 7 May 1969

#22 - TECHNIQUE OF FIRE OF THE RIFLE SQUAD. October 1969.

VOLUME III

APPENDIX II

OPERATIONAL TEST PROCEDURES
AND TECHNIQUES

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1. Introduction. This appendix is designed to be a guide for the test officer in implementing operational service tests of light machine guns. Section 2 describes each of the subtests in terms of the major parameters the essential combat task being duplicated by the subtest and the target presentation scenario. Section 3 describes the recommended method for analyzing the subtest output. The analytical plan includes output from all subtests and does not begin until the subtests have been completed.

2. Subtests. The subtests described below are grouped into 3 sets based on the type of mount used on the test item. Subtest Set 1 uses a tripod mount and requires the gunner/crew to use firing techniques that are normally employed on the tripod; these include fixed fire, traverse and searching fire, and free gun fire. In addition, the fixed fire test is repeated under conditions of limited visibility and the free gun test is repeated under artificial lighting conditions. These firing tests provide a representative set of tasks for evaluation of the machine gun on the tripod mount.

The next set of subtests consists of three field tests using the bipod mount. The free gun firing technique is employed under both day and night conditions and the fixed aiming technique is employed under daylight conditions.

The machine gun is employed on two other mounts, the pedestal mount and the vehicular mount. In either case the tasks required by gunner/crew are similar to those required for the successful employment of the tripod or bipod mounts using one or more of the firing techniques described above. Consequently, separate field tests using the vehicular or pedestal mounts are not recommended. However, should a special requirement exist for testing the LMG with either of these mounts, subtest 1.1, 1.2, and 1.3 should be followed. The subtests are described below. The full sample (36 machine gun/gunner systems) will be used with each system firing once during each subtest. The separate tests may be conducted in any order as long as competing weapons follow each other alternately from trial to trial.

a. Subtest Set 1 - Tripod Mounted Tests. Three tasks using the tripod mount under daylight conditions have been selected from the combination of variables that are available. These are fixed, searching and traversing fire, and free gun. The first and third tasks mentioned above are repeated under conditions of limited visibility.

(1) Subtest 1.1 - Daylight Tripod Supported Test. The target presentation scenario presents, in a simulated attack against the defensive position on the defense facility, several target presentations. Each machine gun crew attempts to engage the targets, under the control of the platoon leader (test officer) using suitable firing techniques. The scenario is shown in Appendix IV; the following paragraph is an outline of the scenario.

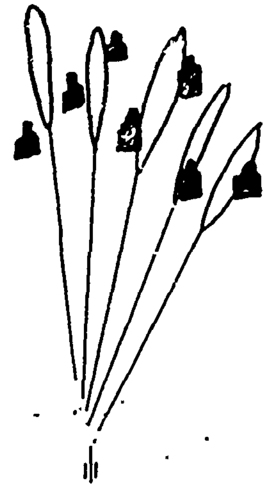
The machine gun and crew occupy the forward firing position. Contact with the enemy occurs at 1100 meters. The crew fixes the aiming point on the center of the array of visible targets. The targets appear repeatedly for short periods. The crew makes the necessary adjustments (reposition sandbags, tighten T&E mechanism) to keep the weapon trained on the target. After about five engagements, more targets appear in the same area causing the crew to begin a searching and traversing action at the command of the test officer. Again, the targets reappear intermittantly causing the task to be repeated. The action continues with the appearance of the 390 target array which will cause the crew to reposition the tripod and begin the searching and traversing action.

After repeated short exposures, array 360 appears. This array is a linear array spread across a large area. The crew is ordered to release the T&E mechanism and begin free gun firing on the tripod. With the disappearance of the last target in this sequence an artillery simulator is fired by the scenario as a signal for the crew to displace tactically. Simulators along the displacement route continue to fire. Upon signal from the test officer via a push button to the computer, the small arms simulators at long ranges begin to fire indicating the commitment of reserve forces. This signal is given as the crew nears the alternate position at the top of the hill. The target presentation sequence is repeated. In each case, the crew should switch from the sustained rate of fire to the rapid rate in the free gun configuration. At least one barrel change should be attempted during that phase of the test.

The measures will consist of hit probability, number of targets hit, time to displace, and number of adjustments to elevation and traversing handles. Two other measures will be recorded for possible use: length of burst and time between bursts.

The long range target array, when all targets are in view, is of sufficient width (45 mils) and depth to require the crew to traverse and search in order to bring effective fire on the entire group when all targets are visible. The weapon will be initially adjusted to bring fire on the right most target of the array (see diagram). The three targets on the right are used as the fixed fire targets.

After each 6-to-9 round burst, 4-to-6 mil increments are made to the hand wheel and quarter turn adjustments are made to



the elevation mechanism until a minimum of six adjustments are made. The rapid rate of fire should be used, that is, the crew should fire as soon as possible after each adjustment. The rapid rate is approximately 200 rounds per minute, 26 bursts of 6-9 rounds each with 1-2 seconds between bursts. The procedure is continued resetting the aim to the initial position until 200 rounds have been fired.

This technique incorporates the crew actions required when using the traverse and search techniques separately and thus reduces the number of cells in the matrix without loss of validity.

In the free gun mode, the crew duplicates the individual tasks required when using the weapon on a pedestal mount thus eliminating more of the cells in the initial design matrix. However, if desired, the entire test may be repeated with the pedestal mount. The crew should use the rapid rate of fire, e.g., 200 rounds per minute with the M60 in 6- to 9-round bursts. There will be 26 bursts with 1-2 seconds between bursts. The scenario requires two barrel changes.

With the barrel changes, additional MOE are time to load and time to change barrel. The sample scenario appears in Appendix IV.

(2) Subtest 1.2 - Tripod Supported Weapon System Under Conditions of Limited Visibility. The machine gun plays an important role in defense of forward or perimeter positions during periods of limited visibility. Predetermined fires are used extensively to engage suspected enemy locations at long ranges and at midranges. The night test will consist of repeating subtest 1.1 under night conditions. Moonlight is desirable since it will facilitate movement between positions and placing the weapon on the tripod. Moonlight will not aid in target acquisition since targets at extreme ranges will not be visible to the firers under these conditions. Firers must rely on simulated weapon signatures for acquisition. The measures and scenario are the same as those specified under Subtest 1.1.

(3) Subtest 1.3 - Tripod Supported Weapon System Under Artificial Lighting Conditions. This subtest is a repeat of subtest 1.2 at night using artificial light. A target presentation scenario may be required using nearer range targets. Maximum and midrange targets may not be visible under artificial light at night. The scenario should use arrays 220, 430, 340, 180, 250 in place of the arrays mentioned above (see Appendix IV). The measures of effectiveness remain the same.

b. Subtest Set 2 - Bipod Mounted Tests. This set of subtests is designed to evaluate weapon system performance when used with the bipod. Identical firing techniques are recommended in FM 23-67 for use with the vehicle mount, and, since the bipod essentially duplicates the combat tasks required with the vehicle mount, the vehicle-mounted stationary machine gun tests can be eliminated if desired, reducing the number of variables that must be considered. Throughout the bipod tests, alternate crews should fire from the fox hole and a prone position adjacent to the fox hole.

(1) Subtest 2.1 - Daylight Bipod-Mounted Test. The initial portion of the scenario is designed to evaluate crew/gunner performance while engaging fixed targets. Each of the gun crews is required to take specific targets under fire as they appear during the initial part of the trial. Three long-range arrays will be used and will be raised. Prior to the start of the test, the gunner will be shown the location of the three arrays and instructed as to which target he should fire at in the array. The gunner should continue to fire at the sustained rate at the preselected target for the entire period the target is in view. The test is designed to fulfill two requirements: measurement of the accuracy of the weapon, and the effects of dispersion, if any. Hit probability and number of targets hit will be the measures of accuracy. The range is designed such that there is more than one target in the beaten zone although only the center target is used as an aiming point. The rear firing position will be used during this phase. Range to the three selected arrays will be 410, 500, and 1170 meters. The scenario requires each array to be raised for 20 seconds (approximately 4 bursts, 6-9 seconds each) sequentially. The presentation is repeated five times to permit 200 rounds to be fired.

At the conclusion of this sequence the platoon leader will order the crew to displace forward to the alternate firing position. The crew will then use the free gun firing technique on the bipod. The target presentation scenario will require the gunner to fire the weapon at a large number of arrays and target configurations with varying exposure times. The Defense Experiment I scenario is recommended for use in this subtest. The primary MOE will be hits on targets. Other MOE, such as hit probability as a function of burst size, will be used for performance optimization analysis. The sustained rate of fire should be used. Movement times will also be recorded.

(2) Subtest 2.2 - Bipod-Mounted Night Firing Test. This subtest is a repeat of Subtest 2.1 above, except that it takes place under conditions of artificial illumination and a shorter version of the Defense I scenario is recommended. The target presentation scenario should consist of the 12-second, fixed exposure periods of the Defense I scenario. This will eliminate single target appearances and shorten the firing time to approximately 4 minutes per trial. The MOE selected for this trial remain the same.

c. Subtest Set 3 - Free Gun Firing Tests. This series of 3 subtests are performed on the Quickfire Facility using various man/weapon interfacing techniques. Each gunner will engage the 26 targets on the facility testing for accuracy at close range and responsiveness. The measures are number of targets hit, burst hit probability, time between rounds, time between bursts, time to first round, and time to shift fire. The three subtests - hip, shoulder, and aimed - are combined into a single test design to compesate for the learning factor. This will permit determination of the best firing technique to permit optimization of weapon performance. Since this is a minor part of the machine gun's combat role, actual decisions concerning selection of the superior weapon system should be made on the results of the previous two subtest sets. Only in the event that one of the weapons failed to show superior performance should these data be used for weapon selection. Consequently, it will not normally be necessary to put both weapons through subtest 3 if the weapons are not close competing weapons; only the superior weapon need be tested.. The schedule of trials for this subtest appears at table 1.

d. If portability and sustainability characteristics appear to be different (i.e., differing sizes of basic load, differing ammunition consumption rates) the attack facility may be used to test the weapon system as part of the maneuver element of the squad. The MOE are number of targets hit, hit probability, movement time, and reload time. The standard attack facility scenario should be used.

## FIRING TABLE

## (MACHINE-GUN A)*

Firing Technique

| Trial | Hip | | | | Underarm | | | | Aimed | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1** | 4 | 7 | 10 | 13 | 11 | 19 | 22 | 25 | 28 | 31 | 34 |
| 1 | 2 | 5 | 8 | 11 | 14 | 17 | 20 | 23 | 26 | 29 | 32 | 35 |
| | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
| | 13 | 16 | 19 | 22 | 25 | 28 | 31 | 34 | 1 | 4 | 7 | 10 |
| 2 | 14 | 17 | 20 | 23 | 26 | 29 | 32 | 35 | 2 | 5 | 8 | 11 |
| | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 3 | 6 | 9 | 12 |
| | 25 | 28 | 31 | 34 | 1 | 4 | 7 | 10 | 13 | 16 | 19 | 22 |
| 3 | 26 | 29 | 32 | 35 | 2 | 5 | 8 | 11 | 14 | 17 | 20 | 23 |
| | 27 | 30 | 33 | 36 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 |

* Firing Table for Machine Gun B the same

** Numbers denote firer number

Table II-1

3. Analytical Procedure. This section describes an analytical plan recommended for use by the test officer. The plan is designed to analyze the data output of the three sets of subtests (four if the attack facility is used) previously described. It is assumed that side by side tests were conducted using two or more LMG systems. Normally, one of the weapon systems tested is assumed to be the weapon currently in the inventory and is referred to as the standard, although a standard weapon is not necessary. All candidates may be prototype weapons. The plan that follows is only a suggested format for the analysis and should be changed or modified as required at any point during the outlined procedure. Condition of the data, sample size, and changing environmental conditions during the test may require deviations from the proposed format.

The objective of the plan is to identify the superior weapon as early as possible in the analysis. Once the superior weapon is identified, the data are then analyzed to determine the relative weaknesses and strengths of the selected weapon.

a. The Test Situation. Operational performance testing is designed to yield estimates of combat effectiveness in terms of damaged inflicted on the enemy. The measures of effectiveness (MOE) are number of targets hit, hit probability, time to first round, time to first hit, and time to shift fire. Other factors such as reliability and sustainability are included in the measure number of targets hit to the extent that they are in combat. That is the number of targets hit will be reduced if the weapon fails to fire or if the entire basic load is expended prematurely. In addition, reliability is measured by manually recording the number and types of failures in each weapon system and the appropriate number of rounds between failures. However, this is done throughout the entire spectrum of the service test and, hence, will be continued during the operational testing phase of the service test. Lastly, displacement times, movement times and reload times are compared.

Two test facilities are normally required for use as test vehicles, the quickfire and defense facilities. Machine guns are normally used in the base of fire role in the attack situation, a task very closely related to the long-range precision fire task of the defense facility. Any use in other attack roles such as fire and movement is similar to the hip, underarm, and shoulder fire of the quickfire facility or the bipod firing on the defense facility. Consequently, the attack facility will not have to be used during the LMG operational service phase unless the weapon is designed to assume this role frequently in combat.

If the attack facility is not necessary a considerable saving in testing effort will be realized.

The validity of the tests data produced on the test facilities is directly dependent on how well the facilities succeed in duplicating the combat tasks which must be performed by the weapon system. The target presentation scenarios must be as realistic as possible in terms of the combat tasks which must be performed by the crew.

b. Test Criteria. The primary criteria for the evaluation of MG performance is accuracy. Sustainability, reliability, and responsiveness are also included in the criteria to the extent possible.

(1) Accuracy. Accuracy MOE include the various hit probability measures, the number of targets hit, and the total number of hits and near miss data.

(2) Sustainability. The standard tasks that are required will test the systems ability in maintaining the sustained rate of fire and the rapid rate of fire, as defined in the field manual. Failure will constitute a system failure and the weapon will be considered ill-suited for the combat environment regardless of its capabilities with respect to other criteria.

(3) Reliability. Weapons which normally reach the operational testing phase of the service test will have received extensive reliability testing during the engineering test phase. Consequently, the expected failure rate will be low. Reliability will be expressed in terms of the mean number of rounds between failures. The sample size acquired during the operational tests should be too small to identify small differences between competing weapons but should contribute to the data base for reliability which is collected from other parts of the service test.

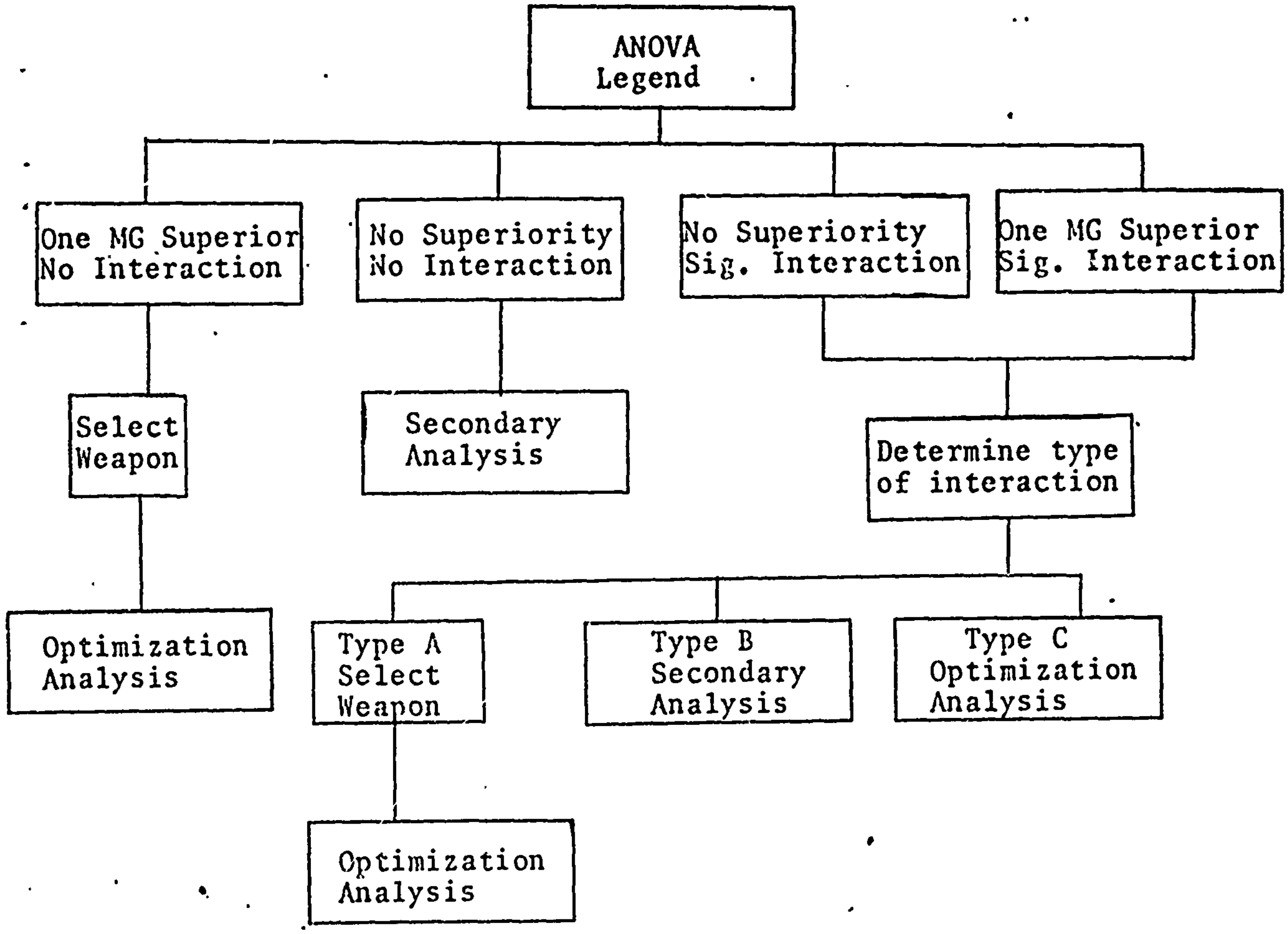
(4) Responsiveness. Since the LMG plays a small role in the quickfire situation, these MOE have been relegated to a lesser role in the performance analysis. The MOE are time to first round, time to first hit, time between trigger pulls, and

time to shift fire. All of these are associated with the quick-fire facility tests.

(5) Portability. The primary measures are displacement time from the defense facility and movement time from the attack facility. If the attack facility is not used, tests on the CET facilities be evaluated for weapon system portability analysis.

c. Field Test Procedures. This subject is discussed under Objective 2, Section 4, where recommendations concerning soldier selection, sample size, weapon assignment, and training are made. A detailed discussion of this topics is available in the document, Integrated Test and Analysis Procedures for Small Arms Weapon Evaluation, USAIB, November 1971. The scheduling of the various subtests is left to the test officer, since each of the tests is independent.

d. Data Collection and Reduction. The data required for this analysis will be collected automatically by the ADPE except for the weapon malfunction data, which are the responsibility of the test officer and must be collected manually. Movement and displacement times may be collected manually and analyzed if desired. The automatically collected movement data will consist of the elapsed time from the last round fired in one position to the first round fired from the alternate or next position. Sample data collection forms for malfunction data are available in Appendix III, Volume I of the Methodology Study Report. Other data required, as a matter of record, are personal histories of test soldiers, illumination levels during night




Legend: Statistical Test - ANOVA
DATA-From Subtests-1.1, 1.2, 1.3, 2.1, 2.2 &3
MOE-No. of Targets Hit

PRIMARY ANALYSIS OF
WEAPON PERFORMANCE

Figure II-1

firing, meteorological data, and ammunition lot number data. These data should be made part of the test record for possible future reference. These data are occasionally very valuable in explaining anomalies in the test findings.

The data reduction is normally handled by the available post event software programs. The reduction should normally follow the procedure outlined below. Occasional deviations from the prescribed plan may be necessary if anamolies or other problems arise during the analysis.

e. Analysis. The initial analysis employs a single MOE. The most valid measure of combat effectiveness is the number of enemy casualties. The number of targets hit while using the test facilities to simulate the combat environment is representative of this measure since the facilities require combat tasks and actions similar to those required in combat. All of these components of combat effectiveness interact within the selected measure, defined as mission accomplishment (MA).

This measure is an encompassing measure and has buried within it the effects of most of the measures now considered important. Table II-1 summarizes the measures of effectiveness (MOE) and indicates either their inclusion or exclusion from MA. The rational for the relationship between MA and MOE is given by MOE in subsequent paragraphs.

Table II-1

| MOE | Attack | Quick Fire | Defense | MA |
|---|---|---|---|---|
| Distribution of near misses | 0 | 0 | 0 | 0 |
| Hit probabilities per trigger pull-automatic mode | X | X | X | X |
| Engagement hit probabilities | X | X | X | X |
| Time to first hit | X | X | X | X |
| Time to first round | X | X | X | X |
| Time between bursts | X | X | X | X |
| Time between hits | X | X | X | X |
| Time to shift fire | X | X | X | X |
| Number of rounds to first hit | X | X | X | X |
| Hits per round | X | 0 | X | X |
| Time to reload | X | X | X | X |
| Number of malfunctions | X | 0 | X | X |
| Time to clear malfunctions | X | X | X | X |
| Time between malfunctions | X | 0 | X | X |
| Number of rounds between malfunctions | X | 0 | X | X |
| Movement times | X | 0 | 0 | X |
| Compatibility with other equipment | X | X | 0 | X |
| Ease of handling in the assault role | X | 0 | 0 | X |
| Sound level recording (blast) | 0 | 0 | 0 | 0 |
| Light reduction | X | 0 | X | X |
| Light emission | 0 | 0 | X | X |
| Ejection Patterns | X | 0 | X | X |

(1) Distribution of near misses. This MOE is not related to MA as defined above.

(2) Hit probabilities per trigger pull--automatic mode *MA $\approx\sum$[(Trigger Pulls at Range I)* (Ph at Range i)-Duplicates Target Hits]

(3) Engagement hit probabilities. *MA $\approx\sum$[(Engagement at Range i)*(Engagement $H_p$ at Range i)-(Average number of targets hit per engagement)] *The "approximately equal to" is caused by the existences of time constraints on target exposure.

(4) Time to first hit (Targets react to hits). If two weapon systems under test have different time to first hits, i.e. $\mu_\alpha > \mu_b$ where $\mu_\alpha$ and $\mu_b$ are the average time to first hits per system, then MA is affected because of the limited target exposure time. Consider a distribution of time to first hit for weapon A as depicted in Figure 7 and a distribution of time to first hit as depicted in Figure 8. Assuming roughly the same standard deviation for both distribution it is evident form Figures 7 and 8 that the curve in Figure 7 has more area to the right of the target exposure time and as a consequence fewer hits would be achieved resulting in a lower MA.

(5) Time to first round. This MOE is related to MA in the sense that time to first round is correlated with time to first hit. The correlation was found to be approximately .65 in the quickfire experiment 1.

Figure 7

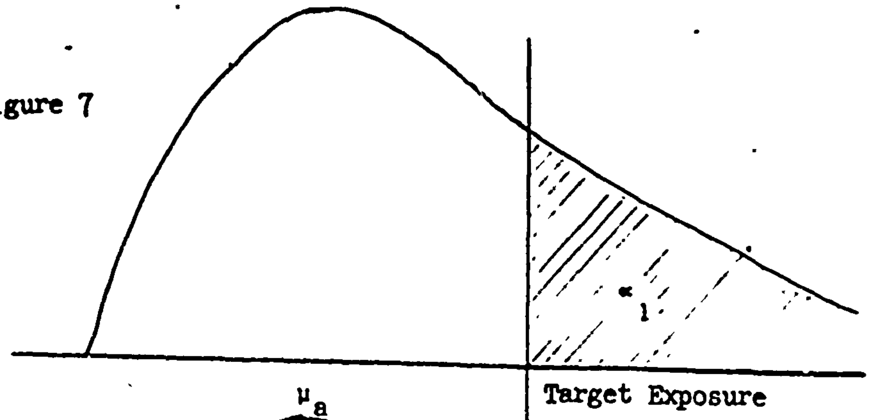
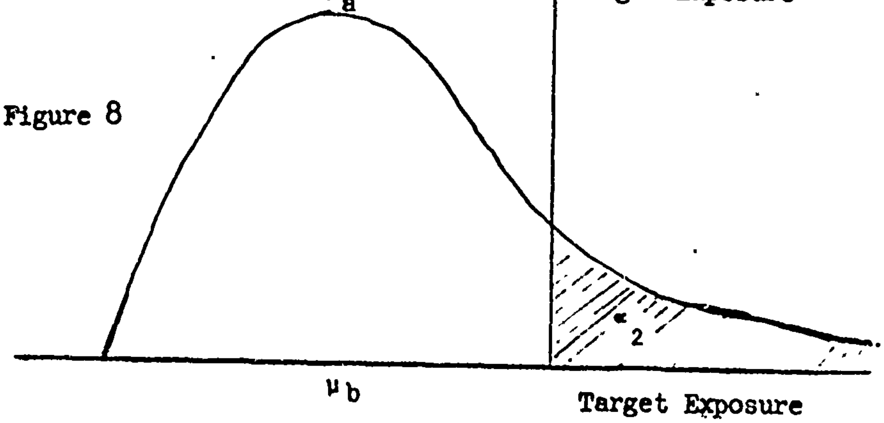



Figure 8




(6) Time between burst. This MOE is related to MA to the extent that a long time between bursts for one weapon system would indicate interface problems and a failure to get rounds down range decreases the value of MA. Given that each round has a potential contribution to MA, any increase in TBB will reduce MA. The quickfire experiment showed a minus correlation between total rounds fired and time between rounds; total rounds fired had a high positive correlation with effectiveness as defined by the discriminant function.

(7) Time between hits. Since targets are normally

exposed for a selected period, an increase in time between hits will decrease mission effectiveness. The logic follows that described for MOE 6, above.

(8) Time to shift fire. This MOE is a good indicator of man/weapon interface problems. A weapon system that performs poorly with respect to this variable would decrease MA, because a soldier is not placing fire on new targets as soon as he could.

(9) Number of rounds to first hit. Related to 4.

(10) Hits per round. This measure is related to the length of the scenario. Realistically long scenarios will be effected by the basic load if it is a weak component of the weapon system. As ammunition runs low, the gunner will typically adjust to a slower rate of fire or will simply fire until out of ammunition completely. In either case, the weapon system ceases to be effective and an impact on the mission accomplishment measure is felt.

(11) Time to reload. If reload time takes longer for one weapon and the scenario is sufficiently taxing then this shortcoming would be reflected in MA for that weapon.

(12) Number of malfunctions. The number of malfunctions is associated with the down time of the weapon. The down time directly reduces the weapon system effectiveness as measured by the mission accomplishment measure.

(13) Time to clear malfunctions. An undesirable weapon performance on anyone of MOE 13, 14, or 15 has the effect of taking the weapon of action thus causing a reduction in MA.

(14) Time between malfunctions. See item 13.

(15) Number of rounds between malfunctions. See item 13.

(16) Movement times. Any weapon characteristic that effects movement time, ease of handling in the assault and perhaps compatibility with other equipment would cause a degradation in MA on the attack facility.

(17) Compatibility with other equipment. See item 16.

(18) Ease of handling in the assault role. See item 16.

(19) Sound level recording. Not part of the MA.

(20). Light reduction (smoke and haze). A weapon performance that in any manner obscures targets would cause a reduction in MA for that weapon.

(21) Visual light emission (flash). This could effect the MA for night test by affecting the individual's darkness adoption.

(22) Ejection Patterns. This MOE would only effect MA if the pattern caused the firer or adjacent firer any discomfort that would tend to reduce his effectiveness.

Since most of the MOE are an integral part of the primary measure, a weapon system that proves to be superior in terms of the mission accomplishment measure on all test facilities may be selected immediately. There is no need to continue the comparative analysis since the superior weapon system has been identified. Emphasis should be placed on the analysis of various MOE to determine whether performance could be improved even more. For instance, although hit probabilities will be adequate at all ranges, they should be examined to determine whether improvements are possible. Time between bursts should be examined to see if modifications could improve the soldier's ability to cope with recoil, reacquire the target, or lay the sights more quickly and effectively. Other areas where potential increases are possible are in optimizing burst size and training procedures. This type of analysis which is designed to optimize weapon system performance differs from the comparative analysis of weapon system performance. Therefore, it is important to determine as quickly as possible which candidate weapon is superior in order to maintain proper orientation of the analysis: optimization vs selection.

Table II-1 shows that 2 measures are not accounted for in the MA measure: sound level and near miss distance. Engineering and safety tests normally monitor such weapon characteristics as signature effects to ensure that the weapon is safe to fire. The tactical significance, however, is not accounted for objectively. Military experience must be used to evaluate the effects of differing signature characteristics as these characteristics affect the vulnerability of the individual/crew or the probability that he will be detected by the enemy. Miss distance is not included in the MA measure since suppression is not a parameter of the test facilities; however, these data can be used in the secondary analysis as a part of the supplementary accuracy analysis.

The analytical technique is a 2 x 6 factorial analysis. The factors are weapons (assuring 2 candidate weapons) and day subtests. The linear model is:

$$Y_{ijk} = U + W_i + S_j + (WS)_{ij} + e_{ijk}$$

Where: $U$ = the overall mean
$W_i$ = $i^{th}$ weapon
$S_j$ = $j^{th}$ scenario
$Y_{ijk}$ = observation corresponding $k^{th}$ soldier the $i^{th}$ weapon during the $j^{th}$ subtest
$e_{ijk}$ = random error

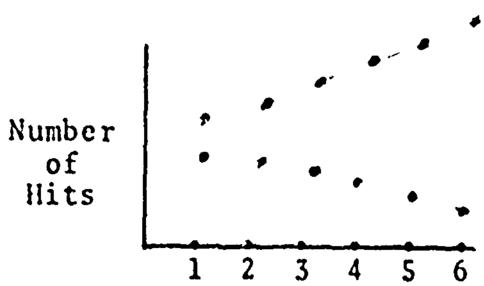
Failure to establish a clear superiority among weapon systems during the primary analysis requires the analyst to procede to the secondary analysis. The secondary analysis must also be performed in the case of a type B interaction or failure to find a significant performance difference between weapons. Each of the possible outcomes of the primary analysis is described below.

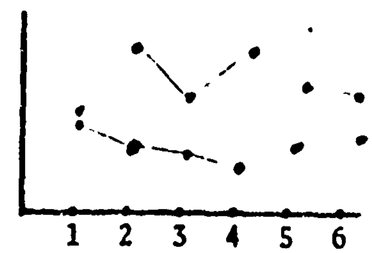
(a) One Weapon Superior Without Interaction. Results of this type show that one weapon performed consistently better over all scenarios. Since these scenarios account for most of the real combat roles of the machine gun, selection of the superior weapon is made and the analysis shifts to performance optimization. During the optimization analysis, performance using several MOE under all firing conditions is reviewed and analyzed to determine if specific performance areas can be improved. For instance, free gun hit probability may be relatively low compared to other methods of employment or other weapons. An improved carrying sling may increase effectiveness Optimization analysis is discussed in more detail in a previously published document, Integrated Operational Test Procedures for Small Arms Weapon System Evaluation, published by the USAIB in November 1971.

(b) No Superiority Without Interaction. These results indicate that the weapons are extremely close in their performance envelopes. Superiority in this category will warrant selection all things being equal to this point. Lack of superiority at this stage leads to the secondary analysis; the new weapon system has not demonstrated an increased level of effectiveness and, consequently, the analysis must be broadened to determine whether significant performance differences exist with respect to other MOE.

(c) No Superiority With Interaction. Both in this case and case (d) below, the existence of an interaction complicates the analysis. The type of interaction must be determined and, if possible, accounted for before selection takes place. The types of interaction are explained in paragraph (d) below.

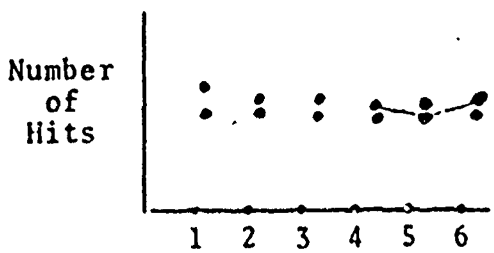
(d) One Weapon Superior With Interaction. Three types of interaction are possible and must be explained regardless of whether or not weapons were found to differ significantly. The type A interaction shows that one weapon is superior but the degree of superiority changes from subtest to subtest. Possible curves are shown below:

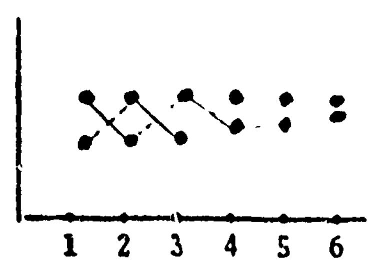



With this type of interaction, if the difference is significant the superior weapon is selected. The next step is to begin optimization analysis.

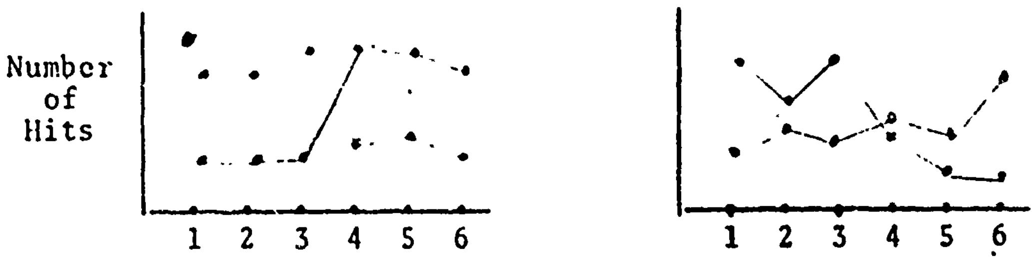
The type B interaction normally occurs where the weapons are relatively close in most subtests. Examples are:



In either of these cases, performance differences are not sufficiently different to warrant selection of a superior weapon. The secondary analysis using other MOE should be undertaken.

The type C interaction is the most difficult to resolve analytically. In this case, one weapon proves superior under one set of conditions but inferior under another set. Some examples appear below:




In this case, performance profiles should be made for both weapons using all available MOE. If the optimization analysis produces no explanation of the interaction, then selection of the superior weapon must be made on the relative importance of the combat roles of each subtest.

(2) Secondary Analysis. This stage of the analysis is reached when the primary analysis fails to show a significant performance difference in terms of number of targets hit. One weapon may still be superior if, for instance, the performance level was reached more efficiently. In other words, identical performance was recorded, but one weapon fired

significantly fewer rounds or was less reliable but still managed to achieve equal performance with the competing weapon. The steps to be followed are a sustainability analysis, a reliability analysis, a responsiveness analysis, an analysis of performance under condition of limited visibility, and an accuracy analysis. If, during one of the steps, one of the weapons is selected as the superior weapon system, the analyst should procede to the Optimization Analysis with next section.

(a) Sustainability Analysis. Using the same basic 2 x 6 factorical design, the analyst should perform an ANOVA using hits per round. Given that performance between competing weapon systems is equal, the relative efficiency becomes the next most important criteria. Increased efficiency means that the weapon system can perform for greater lengths of time for the same system weight. This reduces costs and lessens the impact on the problem of resupply at crucial times in combat.

(b) Reliability Analysis. Assuming that weapons are still competing on an equal basis at this stage of the analysis, reliability becomes an increasingly important factor. Serious reliability problems will have been found by this time, but even minor problems can effect the efficiency of the system. In this analysis, all of the reliability data available from all phases of the expanded service test should be combined. The analysis should take the form of an ANOVA using number of failures, mean time to repair, and mean number of rounds between failures. The number and types of failures should supply the criteria for decision making.

(c) Portability Analysis. This analysis consists of using the data generated while tactically moving or displacing the weapon. The measures are time to displace and time to move as collected from the fire and movement combat action on the attack facility.

(d) Responsiveness Analysis. This analysis consists of using the data generated during the quickfire facility subtests. Four measures are used: time to first round, time to first hit, time between trigger pulls, and time to shift fire. Each of the three firing positions (hip, underarm, and shoulder) should be analyzed separately and comparisons of performance made using the positions found to be optimum for each weapon system. In the event that the service test is evaluation of a submachine gun rather than a LMG, the analytical plan should be changed to that used for evaluating small arms weapon systems.

(e) Analysis of Performance under Limited Visibility. This phase of the analysis uses the data generated in the remaining subtests, which were conducted at night. The analysis uses the primary measure, number of targets hit. The ANOVA statistic test is used.

(f) Accuracy Analysis. This test is a final check to insure that weapon performance parameters are equal as indicated by the preceding steps. An ANOVA is employed using the following measures:

single shot hit probability, burst hit probability, total hits on all targets, and miss distance. Failure to find any meaningful differences indicates that the performance of the competing weapon systems is operationally identical. Any selection of superior weapon systems must be made on criteria other than operational performance. It is assumed that the standard weapon will be chosen since it is already a working inventory item. If this assumption is correct, the analyst should proceed to the Optimization Analysis to determine whether improvements in performance are possible.

(3) Optimization Analysis. This stage of the analysis is reached when the superior is selected or, if there is a standard weapon, no significant differences were found. The purpose of this analysis is to sift through the data base using as many comparative analytical techniques as possible to determine relative weaknesses and strengths of the selected weapon system. It may be possible to improve weapon system effectiveness by making minor modifications in hardware (e.g., a sight change) or a change in firing doctrine (e.g., reduction of burst size).

The recommended method is to prepare graphs of weapon performance as a function of weapon, burst size, firing position, mount, range, and facility using several MOE. The analyst must search for anomalies in the data base which will appear as extreme changes in curve shape or extreme fluctuations from point to point. Various other methods may be employed to search for these anomalies mathematically, such as regression analysis and multivariate discriminant analysis. All of the techniques used during the methodology study are described in a document entitled, Integrated Test and Analysis Procedures for Small Arms Evaluation, USAIB, November 1971.

VOLUME III

APPENDIX III

Technical Data Package
for Test
Facility Expansion

1. Introduction

This technical data package outlines the equipment necessary to add an 800-meter target array consisting of 9 individual targets. The array will be connected to the existing defense facility at No. 3 junction center for control, power and data functions.

2. Cable Requirements

a. Power Cable

The power cable should be at least 6AWG, 3 conductor in order to allow the use of two legs of the 170/208 VAC, 3-phase power on the defense facility. It should be noted that two additional 20-amp circuit breakers will be required in the No. 3 Distribution Center. The 6/3 power cable will be terminated at a junction box (see page 6) located in the target area. A 12AWG, 3-conductor cable is used to distribute power from the junction box to the targets; four targets should be on one leg, five on the other.

b. Control Cable - The control cable should be 16AWG, 19 conductor or equivalent and terminated in the No.3 Distribution Center as shown on page 6 . The cable is terminated in the target area at the LMG Distribution Center (page 7 ). The cables from this Distribution Center to each target are 16AWG, 4 conductor. Two conductors are used for control and two used to supply 40VDC power to Hit Signal Conditioners located at each target (see pages 10 and 11).

c. Data Cable

Coaxial cable, RG-58C/V, should be used for both hit and up indication data. The "hit" cables should be spliced to nine of the existing space coax cables in the No. 3 Distribution Center; the "up indication" cables should be terminated as shown on page 6. It should be noted that the 19 conductor cable used to transmit "up" data should be terminated similarly at the van site to allow coaxial cable input to the van. Utilization of existing cable should minimize the requirement for additional cable as well as minimize the disruption of the existing defense facility.

d. Additional Cable Required

(1) Power Cable: 6AWG/3 Cond 2000 feet

12AWG/3 Cond 1000 feet approximately*

(2) Control Cable: 16AWG/19 Cond 2000 feet

16AWG/4 Cond 2000 feet approximately*

(3) Data Cable: RG-58 C/U Coax 27,000 feet

(13,500' ea for hits and up instructions)

* The cable used in target area is dependent on target dispersion and location of distribution centers.

3. Parts List

a. Power Junction Box with Power Supply

(1) Box 12" x 14" (Hoffman Engineering Co.) (1 ea)

(2) Connectors

(a) Strain Relief Thomas & Betts 2535 (1 ea)

(b) Strain Relief Thomas & Betts 2558 (1 ea)

(c) MS 3102R14S-7S(c) (1 ea)

(d) Split-Bolt 5940-626-2912 (3 ea)

(3) 40 vdc Power Supply

(a). Transformer 6920-600-1479 (1 ea)

(b). Diodes 1H202A (4 ea)

(c). Fuse Holder 5920-993-4823 (1 ea)

(d). Fuse 5A. (1 ea)

(e). Capacitor 7800 MF, 150wvdc (1 ea)

(f). Nichrome wire or equivalent resistor .1 ohm

(g). Circuit Board 4" x 4" (Vector Section of 85-G-25 WE or equivalent) (1 ea)

(h). Wire, 18AWG, Teflon

(i). Necessary mounting hardware for transformer and circuit board.

(b) LMG Range Distribution Center

(1) Box (12" x 14") with plate - Hoffman Engineering Co. (1 ea)

(2) Terminal Strip MS27212-1-20 (2 ea)

(3) Connectors

(a) Strain Relief Thomas & Betts 2534 (1 ea)

(b) Strain Relief Thomas & Betts 2521 (9 ea)

(c) MS 3102R14S-75(c) (1 ea)

(4) Terminal Lugs 5940-577-3711 (72 ea)

(5) Necessary mounting hardware (nuts, clamps, etc.)

Also-Interconnect cable for 40 vdc from Power Junction Box to Distribution Center, 18AWG/3Cond with 2 ea, connectors MS3106E14S-7P

4. Pop-UP Target Assembly (9 each)

(1) Target Mechanism (3C52E) with target holder and connectors MS3102E-16-9S and MS3106E-20-15S (5935-660-4107 and 5935-201-2770) respectively

(2) Target Platform

(3) Position Control Assembly (Ref: IB-001)

(a) Box (6x6) with Plate - Hoffman Engineering Co.

(b) Terminal Strip - Kulka 38TB-10 (5940-983-6087) (1 ea)

(c) Relay - Potter & Brumfield PR11DY (5945-928-6824)

(d) Diode - 1N4001 (1 ea)

(e) Connector - MS3124-16-8P (5935-892-9496) (1 ea)

(f) Strain Relief Connector - Pyle-National Co. DB-9 (2 ea)

(g) Terminal Lug 5940-577-3711 (8 ea)

(h) Wire, 18AWG, Teflon

(4) Connector MS3126F-16-8S (5935-731-0140) (1 ea)

(5) Cable, Interconnect (16AWG, 4Cond, 10" long)

(6) Silhouette - Hit Sensitive

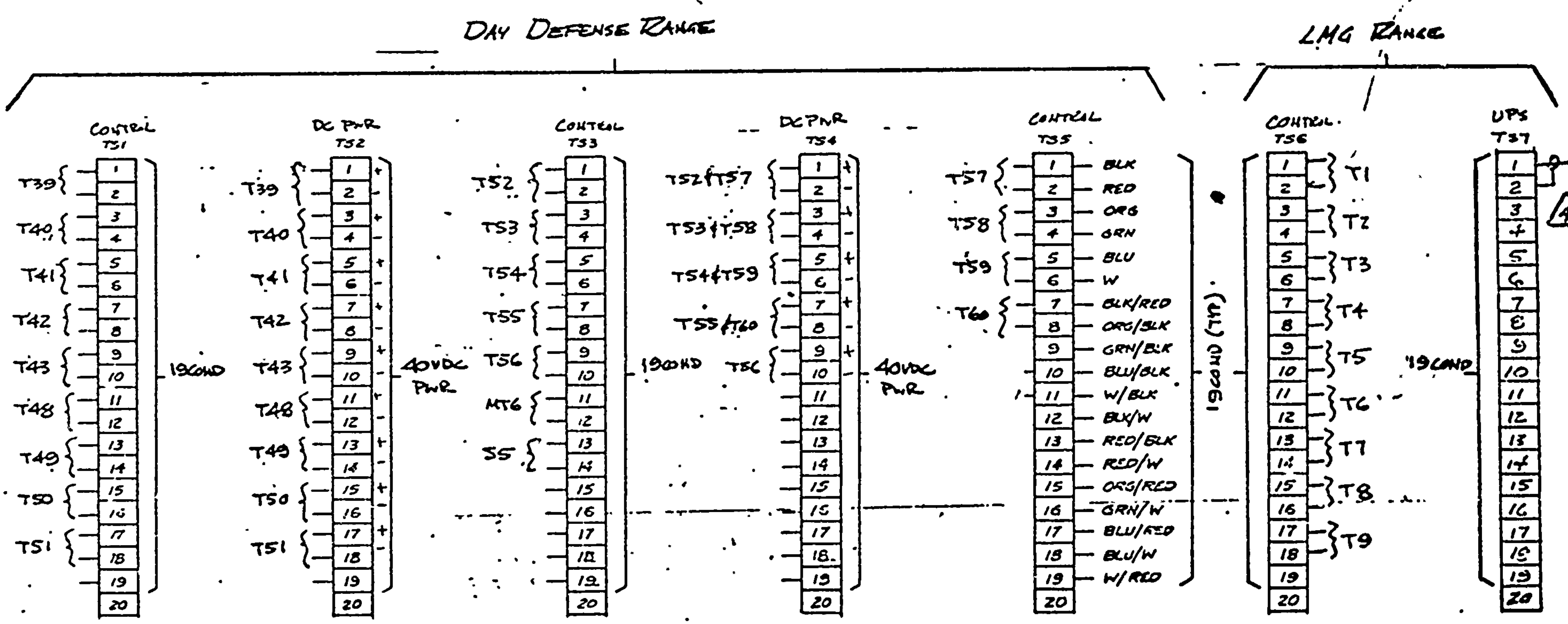
(7) Hit Signal Conditioner (Ref: IB-002 & 003)

NOTE: Use Terminal Lugs, 5940-204-9142, to terminate 12AWG, 3Cond Power Cable as required

(5) Schematics

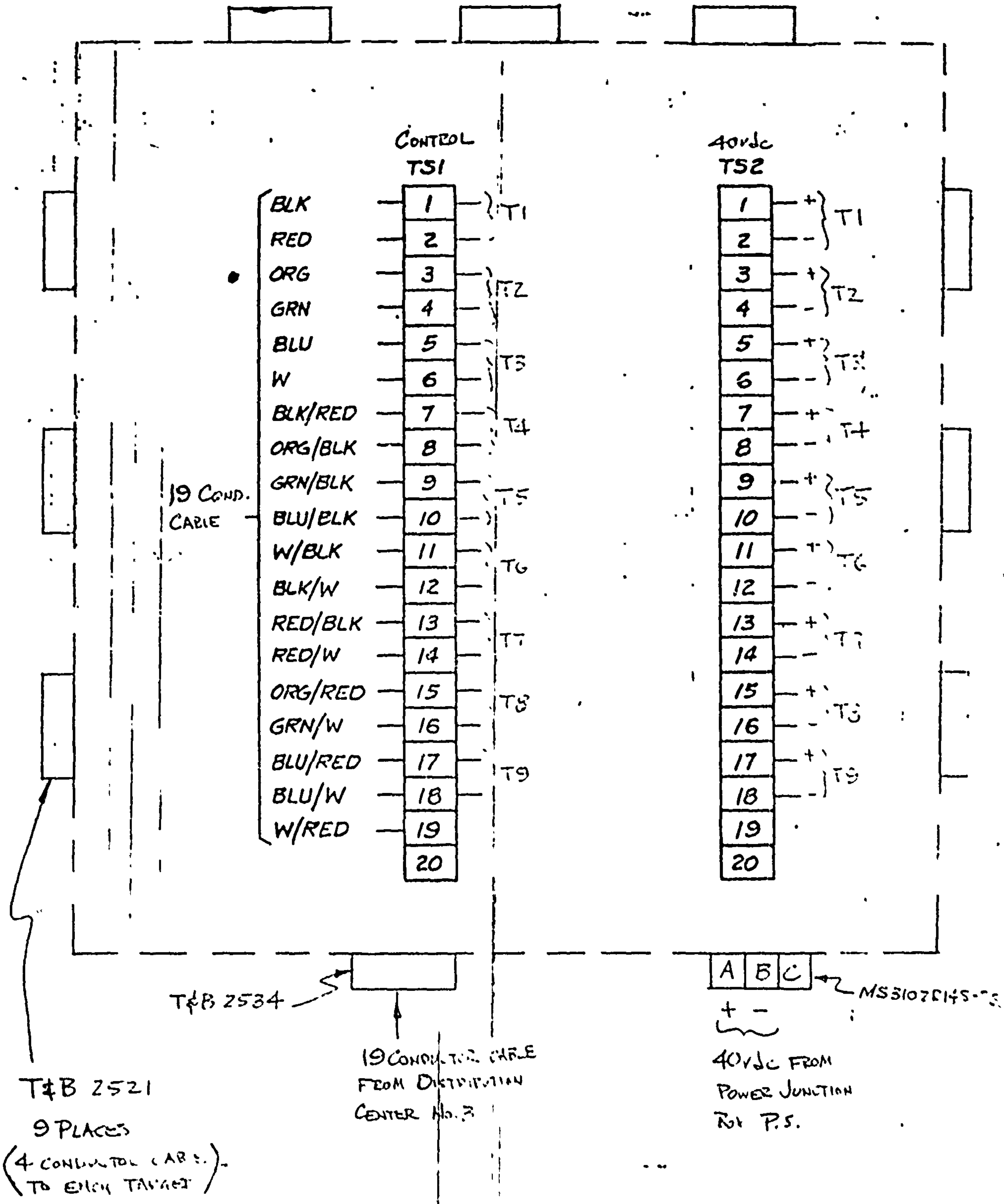
Schematics are attached for reference in installing and checking out the TA800 installation. The first schematic labled DEF-005 described the modifications necessary at control distribution center No. 3 to accept the additional targets into the present system. Schematic 2 is an enlargement of the Light Machine gun range section of center No. 3.

Schematic 3 is a wiring diagram of the power function box. This unit is a transformer which accounts for power loss due to the long transmission line. The next schematic, labeled IB-001, shows the target mechanism control circuit. Schematic IB-002 shows the hit sense signal conditioner. IB-003 shows the hit detector logic circuit.



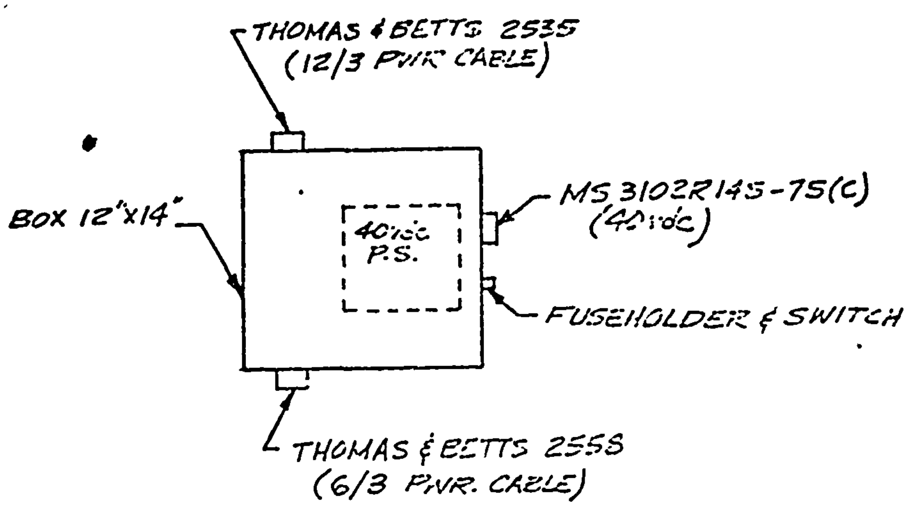

NOTES:
1. 19 CONDUCTOR, 16AWG CABLE TO CONTROL CENTER
2. 4 CONDUCTOR, 16 AWG CABLE TO T42; CABLE NO. 342 (TYP).
3. TERMINAL STRIPS ARE MS 27212-1-20
4. USE COAX. TO EACH TARGET; IT MAY BE NECESSARY TO BIAS THE INPUT (CENTER CONDUCTOR) THRU A 1.5K Ω RESISTOR TO +5Vdc.
5. USE 9 OF THE 12 EXISTING COAX SPARES FOR HIT DATA TRANSMISSION.

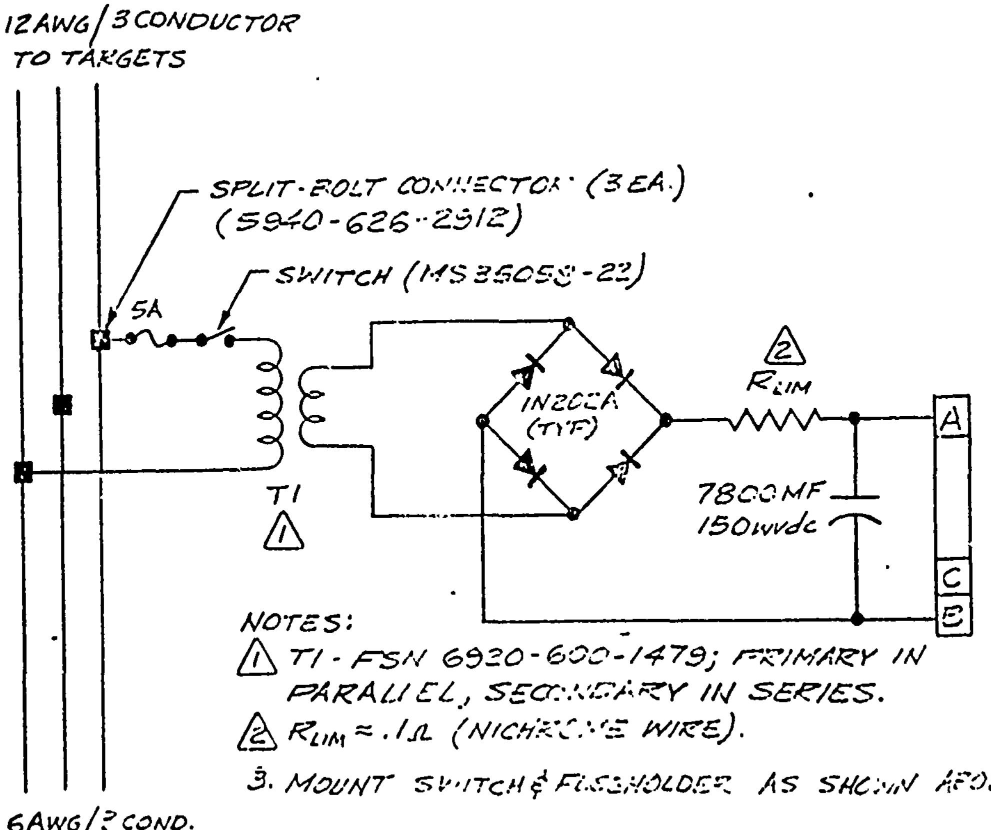
| | | |
|---|---|---|
| U.S. ARMY INFANTRY BOARD | | |
| CONTROL DISTRIBUTION CENTER NO. 3 (MOD) | | |
| N/A / 21 MAY 71 | GC / LITTON | DEF-005 |




LMG RANGE DISTRIBUTION CENTER

SCHEMATIC 2



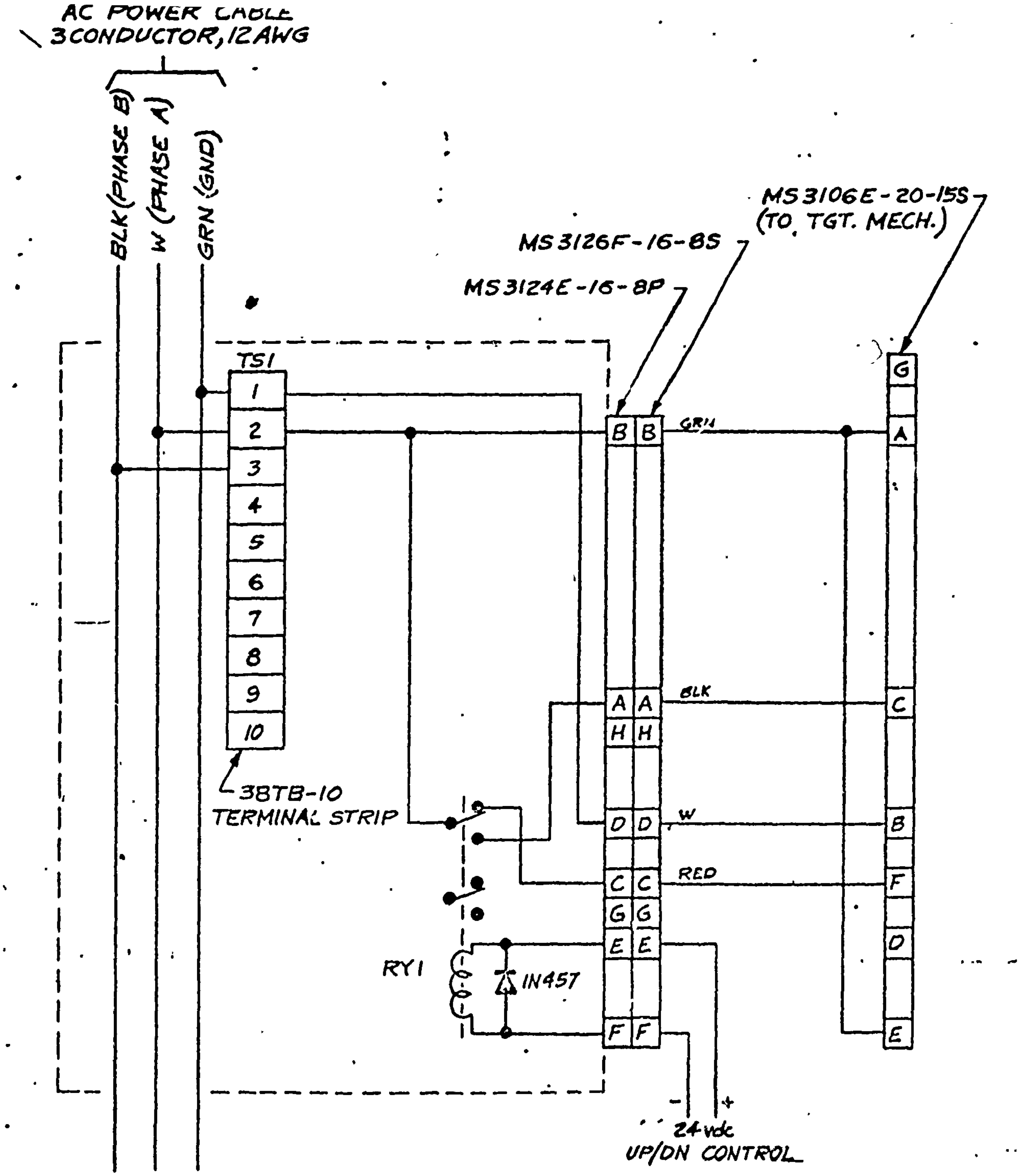




NOTES:

1. T1 - FSN 6920-600-1479; PRIMARY IN PARALLEL, SECONDARY IN SERIES.
2. $R_{LIM} \approx .1\Omega$ (NICHROME WIRE).
3. MOUNT SWITCH & FUSEHOLDER AS SHOWN ABOVE.

POWER JUNCTION BOX

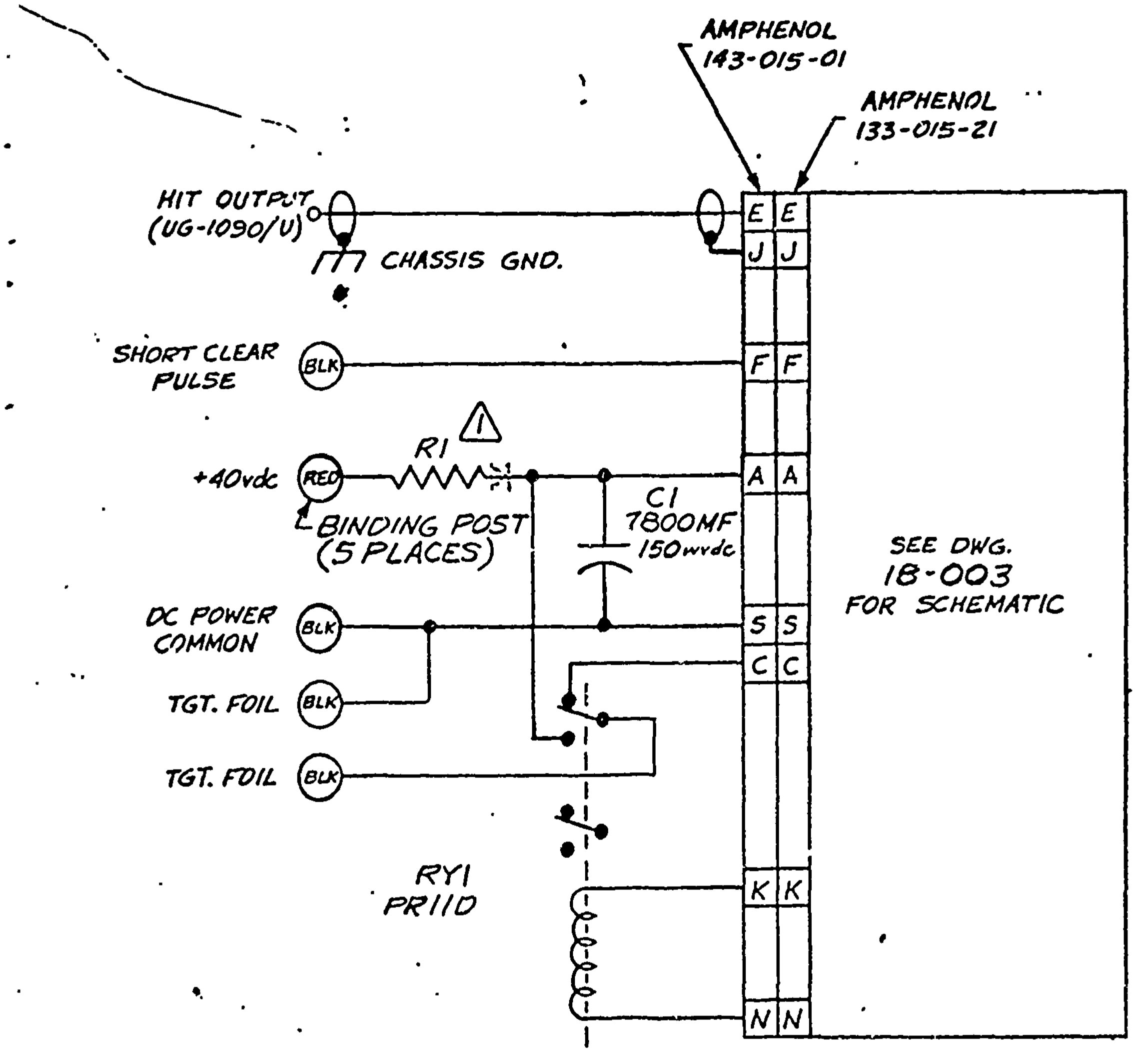
SCHEMATIC 3




NOTES:

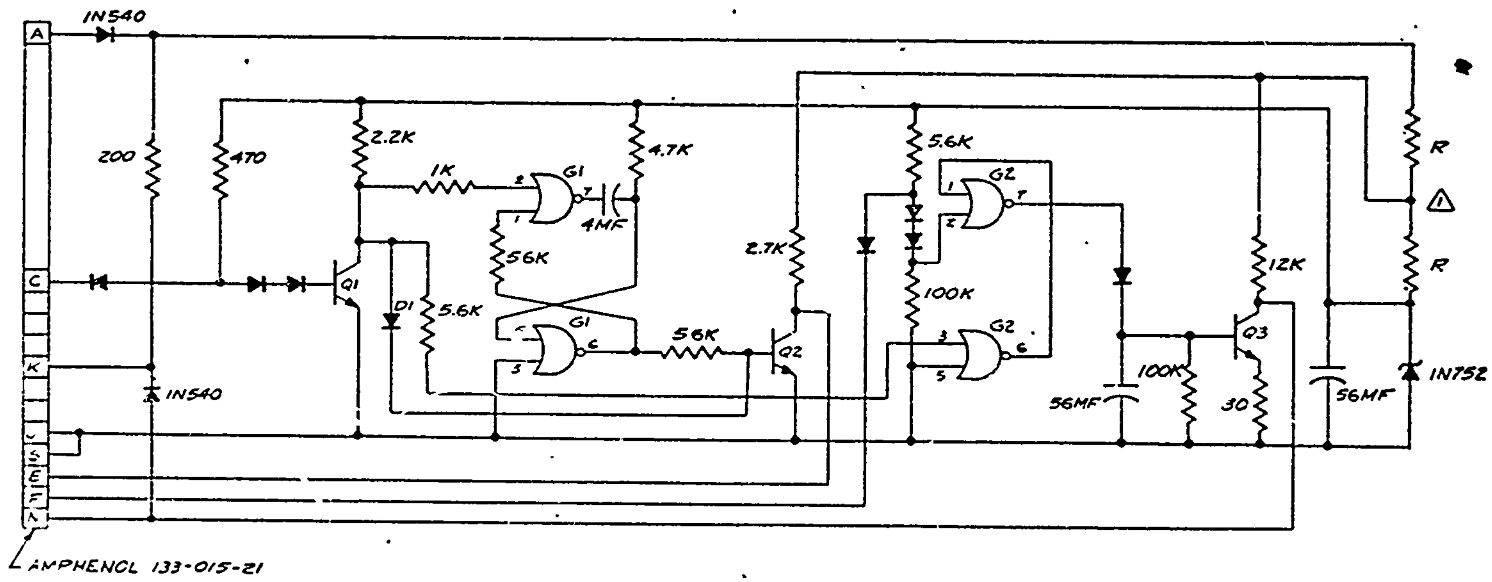
1. RY1 IS POTTER & BRUMFIELD PR11DY RELAY.

| U.S. ARMY INFANTRY BOARD | | |
|---|---|---|
| POP-UP TARGET POSITION CONTROL | | |
| SCALE N/A | DWN GC | IB-001 |
| DATE 19 MAY 71 | DESIGN LITTON | |




NOTES:
1. R1 ≈ 8.7Ω; PARALLEL COMBINATION OF 4 EACH 33Ω, 1/2 W. CARBON

| U.S. ARMY INFANTRY BOARD | | | |
|---|---|---|---|
| POP-UP TARGET HIT DETECTOR | | | |
| SCALE N/A | DWN GC | IB-002 | |
| DATE 19 MAY 71 | DESIGN COZART | | |




NOTES:

1. R = 733 OHMS, PARALLEL COMBINATION OF 3 EA. 2.2K CARBON ½W RESISTORS.
2. G1 & G2 ARE FAIRCHILD 914 NOR GATES; PIN 8 = +5vdc, PIN 4 = GND.
3. UNLESS OTHERWISE SPECIFIED:
   a. ALL DIODES ARE IN457s
   b. ALL TRANSISTORS ARE 2N2222's
   c. ALL RESISTORS ARE ¼W CARBON

| U.S. ARMY INFANTRY BOARD | |
|---|---|
| POP-UP TARGET HIT DETECTOR LOGIC | |
| SCALE N/A / DATE [illegible] / DWN GC / CHECKED [illegible] | IB 003 |

VOLUME III

APPENDIX IV

Additional Target Presentation
Scenarios

VOLUME III

APPENDIX IV

## Additional Target Presentation Scenarios

Existing target presentation scenarios may be used for subtests 2.2, 2.3, 3.1, 3.2, and 3.3. Simple scenarios must be written for Subtests 1.1, 1.2, 1.4, and 2.1. More complex scenarios for the remaining subtests, 1.3 and 1.5, are attached.

## SCENARIO FOR SUBTEST 1.3

After 20 Secs Raise S4 Until after 3 secs.

Raise TA 800 until after 20 secs then GOTO ST2.*

Scan.

ST2: Raise S After 3 Secs. Until after 3 secs.**

Raise TA430 until after 20 secs then GOTO ST3.

Scan.

ST3: Raise S after 3 secs. Until after 3 secs.

Raise TA 800 until after 15 secs then GOTO ST4.

Scan.

ST4: Raise S after 3 secs until after 3 secs.

Raise TA340 after 3 secs until after 20 secs then GOTO ST5.

Scan.

ST5: Raise S after 3 secs until after 3 secs.

Raise TA 800 until after 10 secs then GOTO ST6.

Scan.

ST6: Raise S after 3 secs until after 3 secs.

Raise TA430 until after 15 secs then GOTO ST7.

Scan.

ST7: Raise S after 3 secs until after 3 secs.

Raise TA 390 until after 15 secs then GOTO ST8.

Scan.

ST8: Raise S after 3 secs until after 3 secs.

Raise TA 340 until after 20 secs then GOTO ST9.

Scan.

ST9: Raise S after 3 secs until after 3 secs.

Raise TA 360 until after 20 secs then GOTO ST10.

Scan.

ST10: Raise S after 3 secs until after 3 secs.

Raise TA 390 until after 10 secs then GOTO ST11.

Scan.

ST11: Raise S after 3 secs until after 3 secs.

Raise TA 340 until after 15 secs then GOTO ST12.

Scan.

ST12: Raise S after 3 secs until after 3 secs.

Raise TA 360 until after 15 secs then GOTO ST13.

Scan.

ST13: Raise S after 3 secs until after 3 secs.

Raise TA 340 until after 10 secs then GOTO ST14.

Scan.

ST14: Raise S after 3 secs until after 3 secs.

Raise TA 360 until after 10 secs then GOTO ST15.

Scan.

ST15: Raise S4 after 3 secs until after 3 secs.

Raise TA 800 until after 20 secs then GOTO ST16.

Scan.

ST16: Raise S5 until after 3 secs.

Raise TA 430 until after 20 secs then GOTO ST17.

Scan.

ST17: Raise S until after 3 secs.

Raise TA 800 until after 15 secs then GOTO ST18.

Scan.

ST18: Raise S until after 3 secs.

Raise TA 390 until after 20 secs, then GOTO ST19.

Scan.

ST19: Raise S until after 3 secs.

Raise TA 800 until after 10 secs then GOTO ST20.

Scan.

ST20: Raise S until after 3 secs.

Raise TA 430 until after 15 secs then GOTO ST21

Scan.

ST21: Raise S until after 3 secs.

Raise TA 390 until after 15 secs then GOTO ST22.

Scan.

ST22: Raise S until after 3 secs.

Raise TA 340 until after 20 secs then GOTO ST23.

Scan.

ST23: Raise S until after 3 secs.

Raise TA 360 until after 20 secs then GOTO ST24.

Scan.

ST24: Raise S until after 3 secs.

Raise TA 390 until after 10 secs then GOTO ST25.

Scan.

ST25: Raise S until after 3 secs.

Raise TA 340 until after 15 secs then GOTO ST26.

Scan.

ST26: Raise S until after 3 secs.

Raise TA 360 after 3 secs until after 15 secs then GOTO ST27.

Scan.

ST27: Raise S until after 3 secs.

Raise TA 340 until after 10 secs then GOTO ST28.

Scan.

ST28: Raise S until after 3 secs.

Raise TA 360 until after 10 secs then GOTO STOP.

END)

* TA 800 is Target Array 1100

** Simulator numbers to be added at compilation

SCENARIO FOR SUBTEST 1.5

After 20 secs Raise S until after 3 secs.

Raise TA 430 until after 20 secs then GOTO ST2.

Scan.

ST2: Raise S after 3 secs until after 3 secs.

Raise TA 340 until after 20 secs then GOTO ST 3.

Scan.

ST3: Raise S after 3 secs until after 3 secs.

Raise TA 430 until after 15 secs then GOTO ST4.

Scan.

ST4: Raise S after 3 secs until after 3 secs.

Raise TA 250 until after 20 secs then GOTO ST5.

Scan.

ST5: Raise S after 3 secs until after 3 secs.

Raise TA 430 until after 10 secs then GOTO ST6.

Scan.

ST6: Raise S after 3 secs until after 3 secs.

Raise TA 340 until after 15 secs then GOTO ST7.

Scan.

ST7: Raise S after 3 secs until after 3 secs.

Raise TA 250 until after 15 secs then GOTO ST8

Scan.

ST8: Raise S after 3 secs until after 3 secs.

Raise TA 220 until after 20 secs then GOTO ST9.

Scan.

ST9: Raise S after 3 secs until after 3 secs.

Raise TA 180 until after 20 secs then GOTO ST10.

Scan.

ST10: Raise S after 3 secs until after 3 secs.

Raise TA 250 until after 10 secs then GOTO ST11.

Scan.

ST11: Raise S after 3 secs until after 3 secs.

Raise TA 220 until after 15 secs then GOTO ST12.

Scan.

ST12: Raise S after 3 secs until after 3 secs.

Raise TA 180 until after 15 secs then GOTO ST13.

Scan.

ST13: Raise S after 3 secs until after 3 secs.

Raise TA 220 until after 10 secs then GOTO ST14.

Scan.

ST14: Raise S after 3 secs until after 3 secs.

Raise TA 180 until after 10 secs then GOTO ST15.

Scan.

ST15: Raise S after 3 secs until after 3 secs.

Raise TA 430 until after 20 secs then GOTO ST16.

Scan.

ST16: Raise S until after 3 secs.

Raise TA 340 until after 20 secs then GOTO ST17/

Scan.

ST17: Raise S until after 3 secs.

Raise TA 430 until after 3 secs then GOTO ST18.

Scan.

ST18: Raise S until after 3 secs.

Raise TA 250 until after 20 secs then GOTO ST19.

Scan.

ST19: Raise S until after 3 secs.

Raise TA 430 until after 10 secs then GOTO ST20.

Scan.

ST20: Raise S until after 3 secs.

Raise TA 340 until after 15 secs then GOTO ST21.

Scan.

ST21: Raise S until after 3 secs.

Raise TA 250 until after 15 secs then GOTO ST22.

Scan.

ST22: Raise S until after 3 secs.

Raise TA 220 until after 20 secs then GOTO ST23.

Scan.

ST23: Raise S until after 3 secs.

Raise TA 180 until after 20 secs then GOTO ST24.

Scan.

ST24: Raise S until after 3 secs.

Raise TA 250 until after 10 secs then GOTO ST25.

Scan.

```
ST25: Raise S  until after 3 secs.

Raise TA 220 until after 15 secs then GOTO ST26

Scan.

ST26: Raise S  until after 3 secs.

Raise TA 180 until after 15 secs then GOTO ST27

Scan.

ST27: Raise S  until after 3 secs.

Raise TA 220 until after 10 secs then GOTO ST28.

Scan.

ST28: Raise S  until after 3 secs.

Raise TA 180 until after 10 secs then GOTO STOP.

SCAN.

STOP.

END..
```